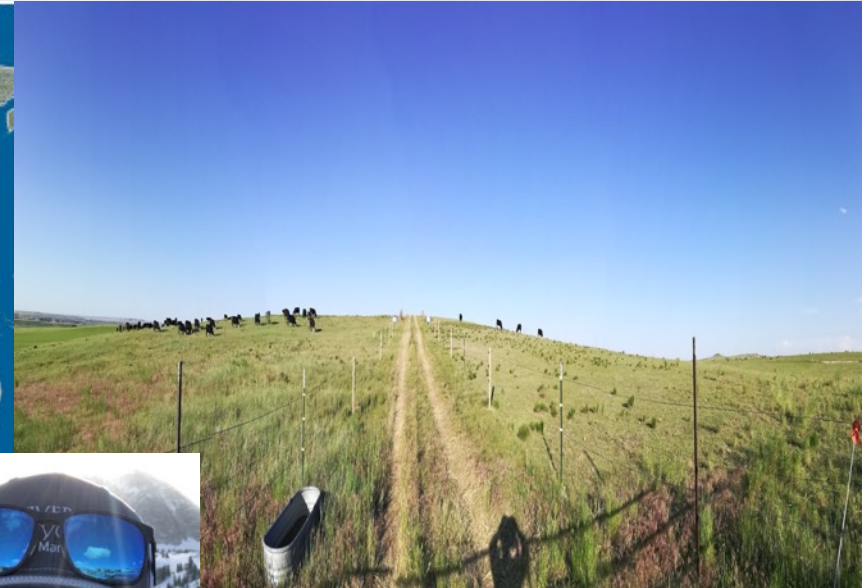
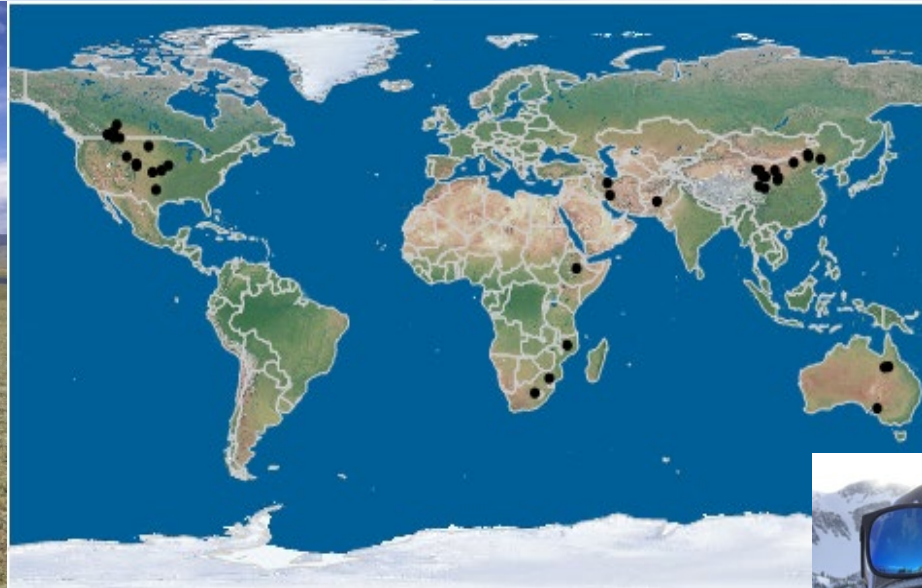




Usable Science for Producers: Helping Cattle Producers Make More Informed Decisions about Soil Health and Grazing



Timm Gergeni
tgergeni@uwyo.edu



UNIVERSITY OF WYOMING

Original Research Task: Practical Aspects of Rangeland Soil Health for Ranchers

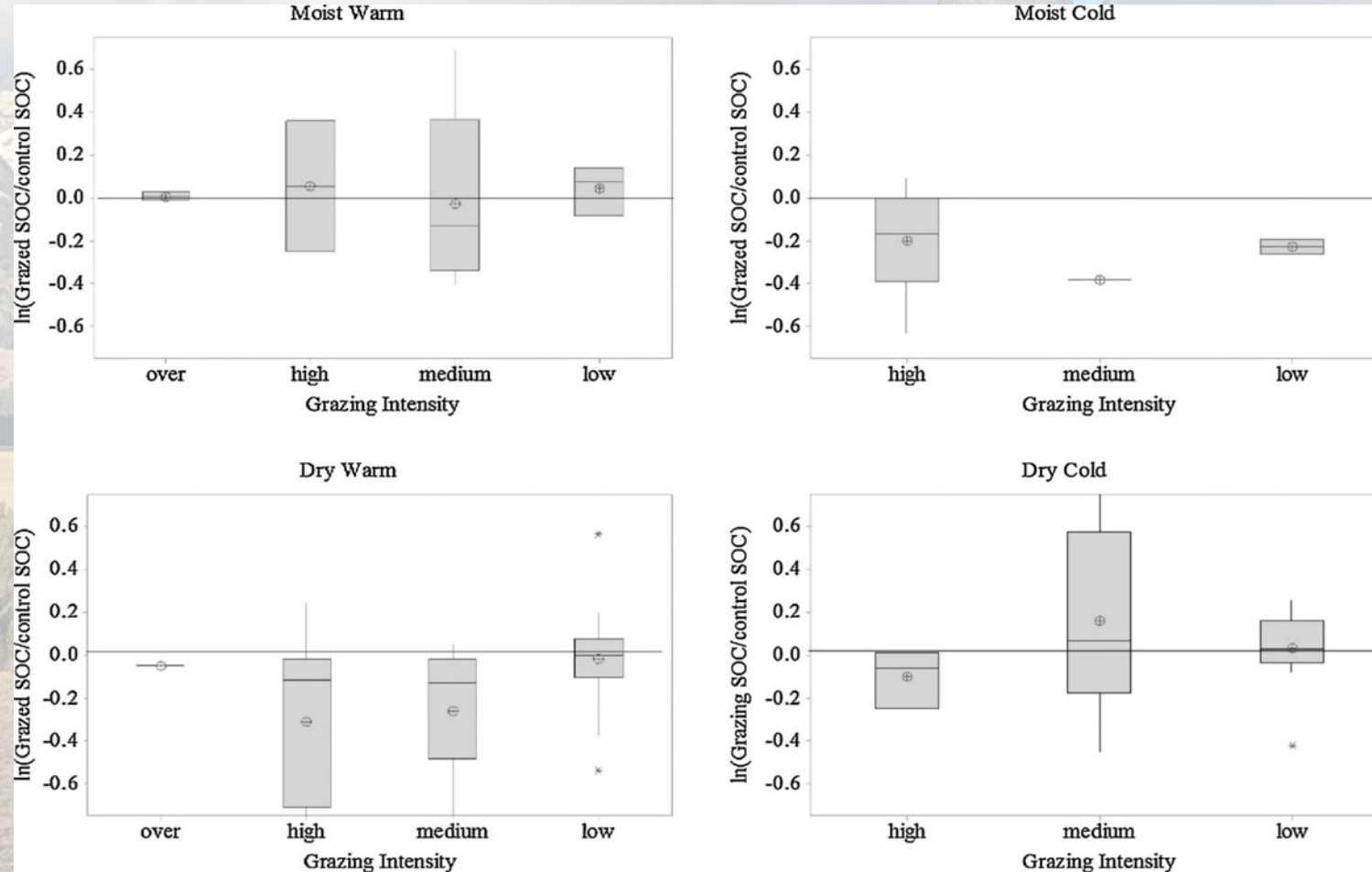
- Practical (despite current progressive grazing and soil monitoring trends, not all grazing management and sampling practices may be practical, or applicable, to Wyoming rangelands)
- *Practical for Ranchers to simply monitor themselves their management effect on soils over time for profitable, sustainable cattle production. (not solely for carbon sequestration or storage)
- “What and how should we be monitoring and why?” - *Producers*
- Data-driven research and review to provide credible information and advice to regional producers seeking input.

What We Know (or don't know) About Rangeland Soil Health and Grazing from Empirical Research and Reviews

- Long-term grazing at different intensity levels significantly reduced SOC (Li et al., 2008, Ma et al., 2016).
- Soil properties in northern temperate pastures do not vary with management practices and are independent of rangeland health (Pyle et al. 2018).
- Low to medium grazing intensity increases SOC in dry cold environments according to Han et al. (2008).
- Comparison of multiple sites with consistent sampling and reporting methods revealed no general trend in the response of soil carbon to grazing in the northern Great Plains (Henderson et al. 2004).
- Grazing at high and low intensities increased SOC, as a result of changes in plant species composition Reeder and Schuman (2002).
- Li et al. (2012) was unable to detect any effect of grazing management on SOC after 58 years. The slow rate change of soil C suggests the rich black grassland soils appear to tolerate intensive grazing.
- Ultimately, the obscurity, transferability, and practicality of soil health monitoring and decision making application have persistently challenged the advancement of rangeland soil health (Derner et al. 2016).

What We Do Know

There is a point where productivity is determined by the environment and climate that the soil is in, not inputs or management (Ward 2021).



Abdalla, M., Hastings, A., Chadwick, D.R., Jones, D.L., Evans, C.D., Jones, M.B., Rees, R.M. and Smith, P., 2018. Critical review of the impacts of grazing intensity on soil organic carbon storage and other soil quality indicators in extensively managed grasslands. *Agriculture, Ecosystems & Environment*, 253, 62-81.

Soil Organic Matter and Soil Organic Carbon

- The hub of the terrestrial carbon cycle is soil organic matter. It contains 50-58 percent carbon by dry weight. Due to their strong linear relationship, producers may choose either soil organic matter or soil organic carbon as practical management indicators as long as they consistently monitor only one.
- The “fuzziness” of soil organic matter, carbon, grazing, sampling, and reporting terminology increases the uncertainty about the causes of change in soil carbon and decreases producer comprehension.
- Some research has leaned toward comparing two areas with different management histories, rather than monitoring one place over time.
- Soil carbon can be divided into various categories, and there are two commonly measured attributes: Trend, or percentage change in soil carbon or mass quantity; OR tonnage of soil carbon, per hectare. Conclusions about trend in soil carbon require measurement of only one parameter: carbon percentage in soil.
- What you measure, along with how you measure it, depends on your purpose-why you are doing it, and what you are going to do as a result.
- For purposes of feedback to management, or establishing that management is affecting soil health, percentage may be all ranchers need (Ward, N. 2021)

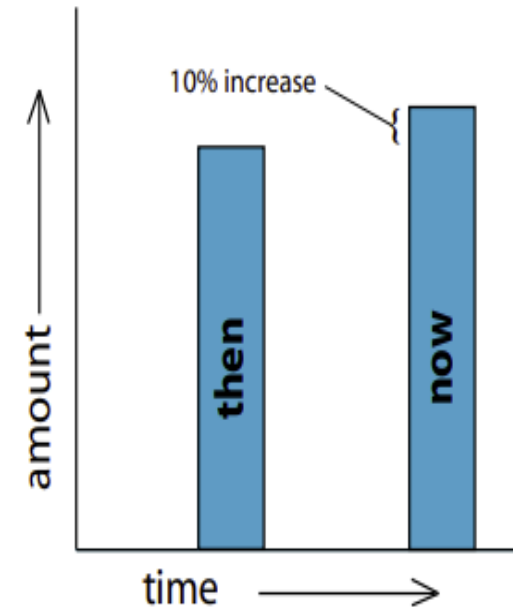
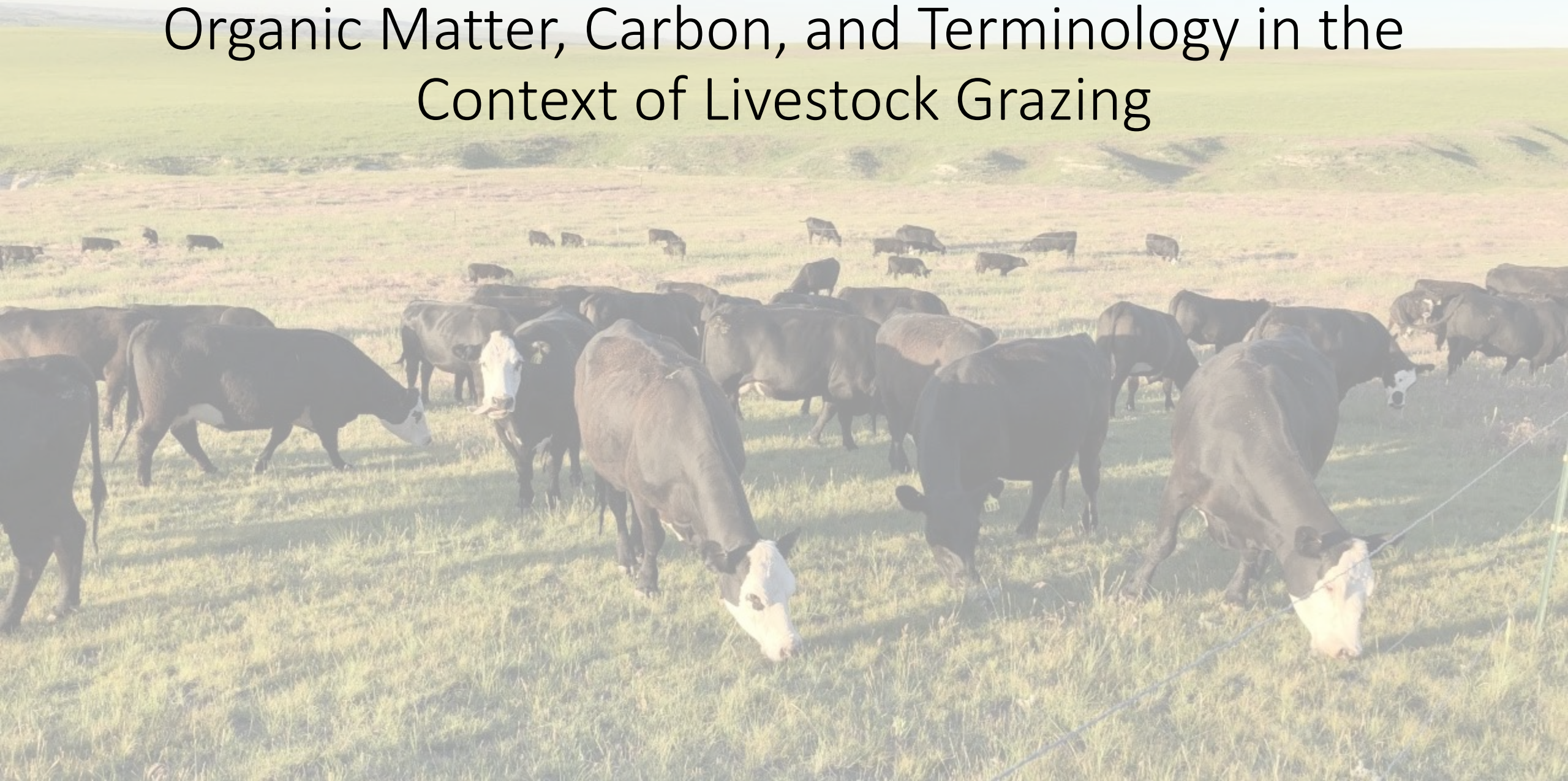


Figure 2.1: Measuring soil carbon change is **simple**. It requires 1) two samplings or measurements of the same soil area, at different times; 2) accurate sampling and laboratory analysis; and 3) more than just one or two samples; 4) commitment and patience, as the *then* must be established well before the *now*.

Donovan, P., 2012. Measuring soil carbon change. *A flexible, practical, local method*.

Global Systematic Review of Rangeland Soil Organic Matter, Carbon, and Terminology in the Context of Livestock Grazing



Scope and Background:

- On global rangelands primarily used for livestock grazing due to their inherent properties and limitations for other intensive agriculture, soil health has become a point of interest with persistent questions from producers.
- Producers frequently question what soil parameters they should be monitoring- if any, and what exactly they are supposed to do with lab results.
- The complexity and confusion surrounding rangeland soil health may in part be a function of the dynamic array of lab analyses, affordability, and reporting and terminology discrepancies resulting in lack of producer comprehension and applicability.

Rationale: What is soil health and how do we practically measure it?

- According to the USDA NRCS, soil health is defined as *the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals and humans* (NRCS 2017; Doran and Zeiss 2000; Karlen et al. 2001).
- Specifically, soil health is measured by many physical, chemical, and biological properties (Cardoso et al. 2013) through an array of field and laboratory analysis techniques.
- Due to SOM's physical stability (Dormaar et al. 1977), affordability of analysis (Ward, N. 2021), and contribution to each of the physical, chemical, and biological soil properties (comprehensiveness), it could be argued that SOM is the most practical indicator of rangeland soil health for ranchers.

Why is SOM the Most Practical Rangeland Soil Health Indicator?

- Cost, Stability, Contribution, and Comprehension
- Cost: OM ~\$5.00 vs. PLFA ~\$80.00 (biological community) + ~\$50.00 Haney (soil health) + ~\$19.00 Soil Analysis (chemical) + ~\$0-?? Physical (field and lab) per sample. \$5.00 vs. > \$150.00 per sample
- Stable: physical state does not fluctuate in the short term relative to current environmental conditions, as many of the chemical and biological responses may. Therefore, a suitable baseline.
- Contribution: organic matter positively influences all properties of soil health; physical, chemical, and biological. Why would ranchers measure them all?
- Comprehension: If you do not have soil organic matter, you simply do not have soil health and or soil quality or really anything to measure.
- Excellent indicator of grazing mismanagement.

Review Goals

- To understand the available research on the effects of grazing on semi-arid rangeland soil organic matter (SOM) and carbon (SOC), by systematically reviewing the global scientific literature.
- Utilize the information and outcomes of this review as a tool to provide regional producers with potential explanations and information about grazing and soils and dispel any misinformation.
- Create a unique dialogue niche that has been missing for future discussions with rangeland livestock producers about the practicality of rangeland soil health monitoring to inform grazing management decisions.

Search Terms

Grazing Terms

- Grazing
- Rotational Grazing
- Stocking Rate
- Grazing Management

Soil Health Terms

- Soil Organic Matter
- Soil Organic Carbon

*Google Scholar and Summon 2.0 online databases

Search Criteria

- Peer-reviewed studies explicitly exploring the effects of cattle, sheep, horses, or livestock (combination) on soil organic matter or soil organic carbon on native rangeland. Studies were not considered if any species other than the 3 previously identified were included (i.e. wildlife). Exclusion also occurred if studies were conducted on irrigated, fertilized, plowed, tilled, drilled, seeded, burned (intentionally), forested, herbicide applied, based on simulation models, mesocosms, or any other site deemed unnatural or highly unique (i.e. saline, sodic, extreme pH values, peats, riparian areas), or lacking a reference ungrazed control.

Data Extraction

- Location
- Year
- SOM/SOC response vs. ungrazed control
- Grazing treatments
- Grazing treatment age
- Ungrazed control age
- Year 1 Baseline reference (Y/N)
- Animal
- Annual Precipitation
- Annual Temperature
- Soil Type
- Samplings depths
- Stock density or stocking rate reference (Y/N)
- Annual forage production reference (Y/N)
- Study location type (ranch-scale, experiment station, or communal)

Results

- ~1,000 peer-reviewed studies reviewed
- 2010 average publication date of empirical studies
- Studies ranged from 1977-2021 (publication date)
- 42 different empirical studies identified
- 60 sites (data generally summarized by site)
- 107 total grazed to ungrazed comparisons
- 4 continents
- 9 countries
- 13 reviews or syntheses identified (not included)

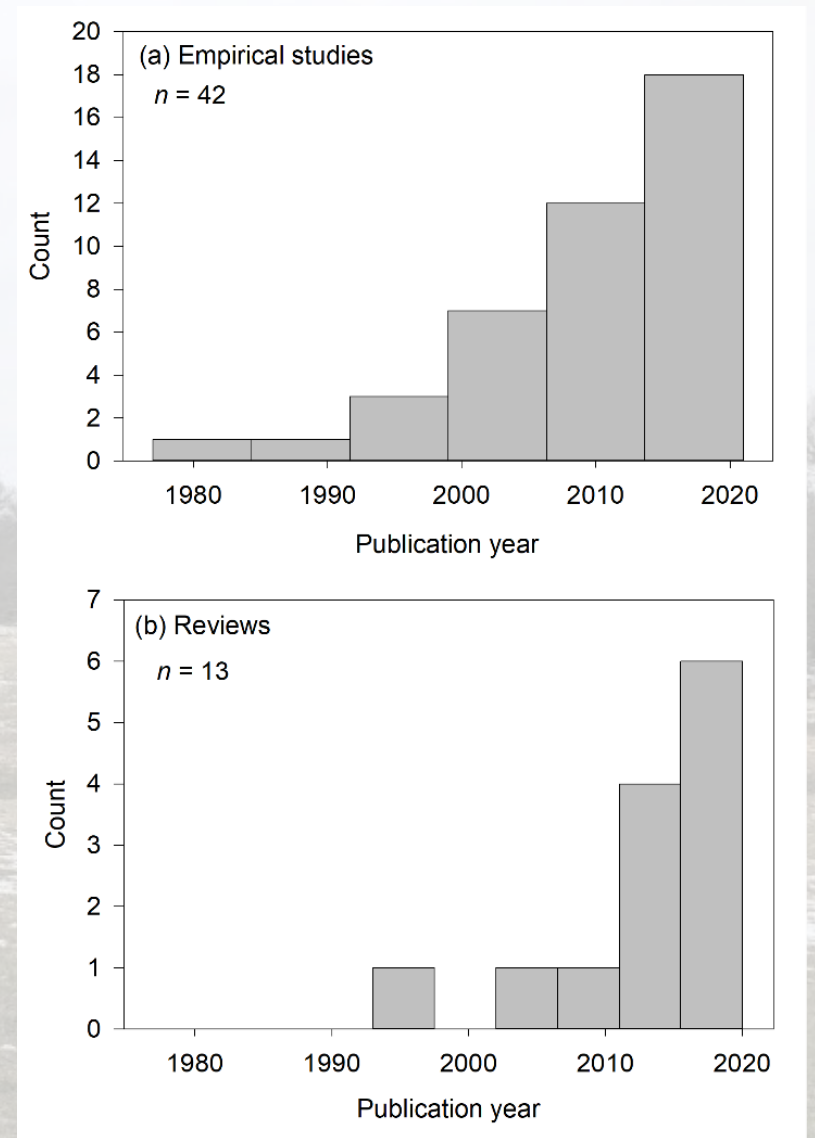
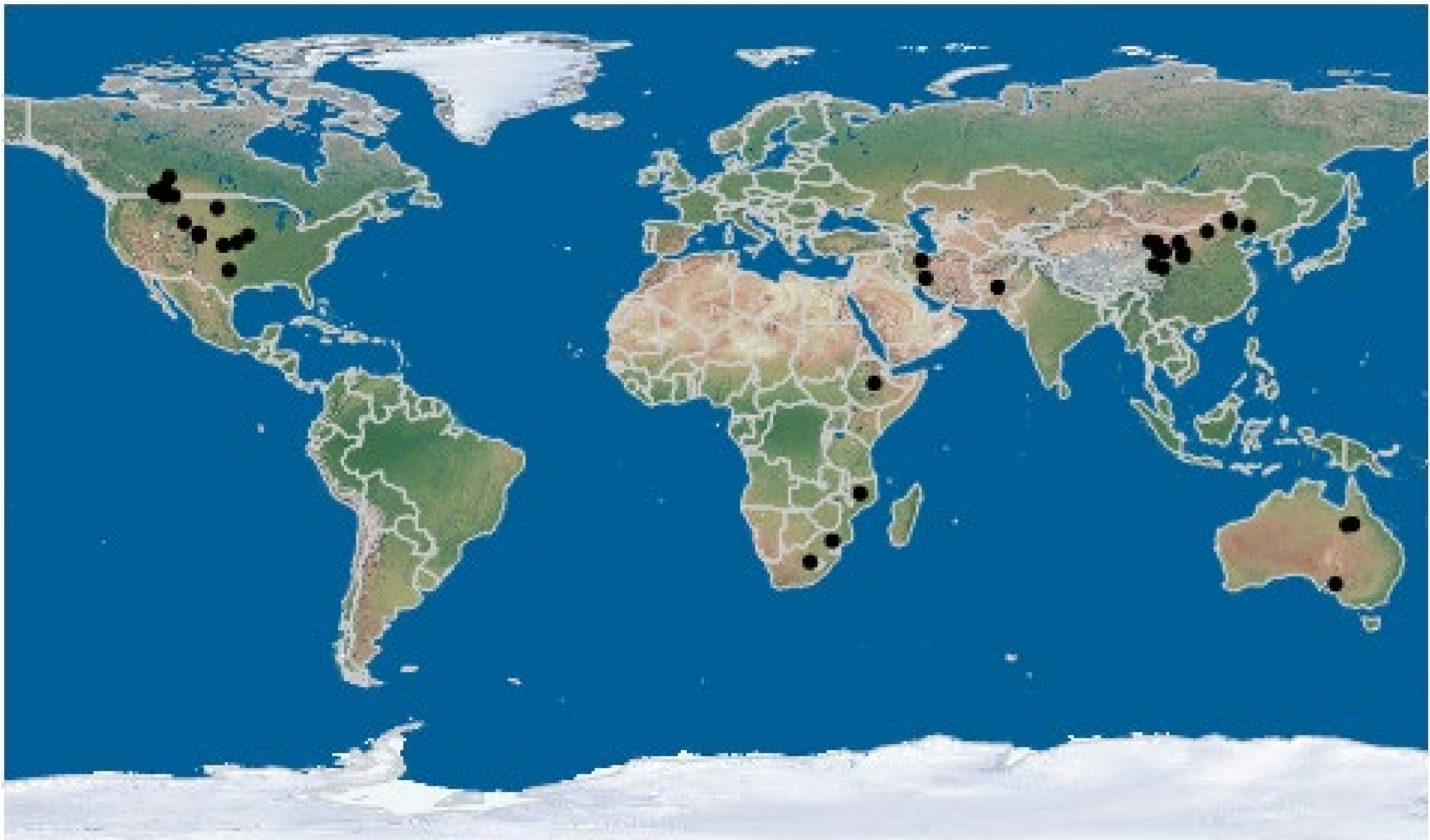


Figure 1.2 Rangeland grazing, soil organic matter, carbon, and terminology global-review year of publication histogram. Forty two publications from 1977-2021 met the inclusion criteria found in Table 1.2. Mean year of publication was 2010.

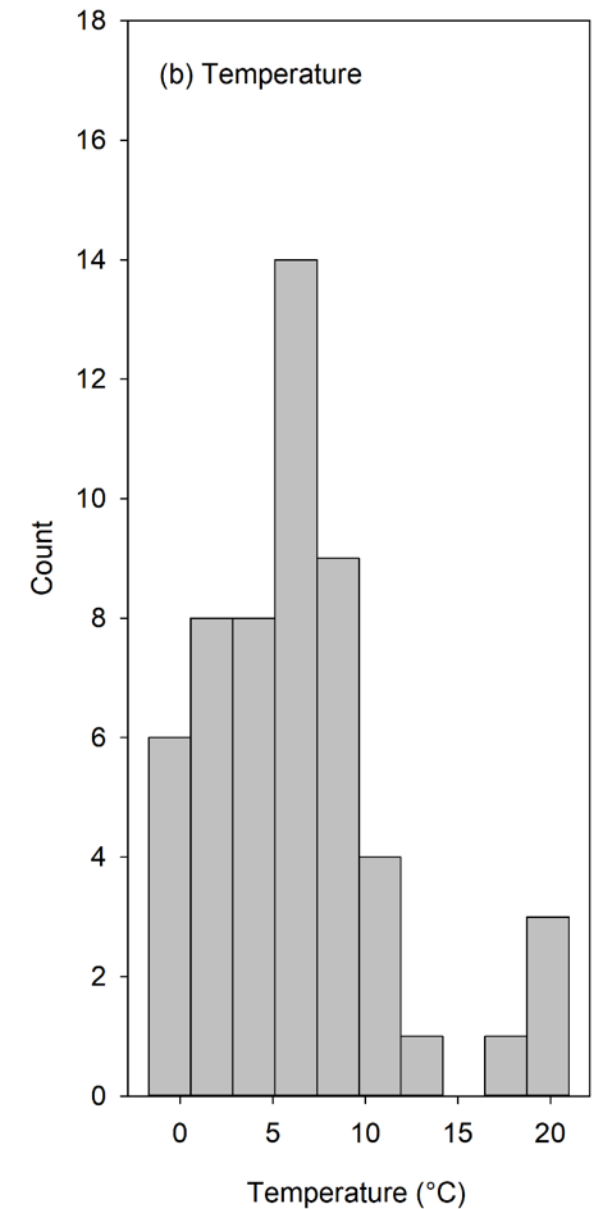
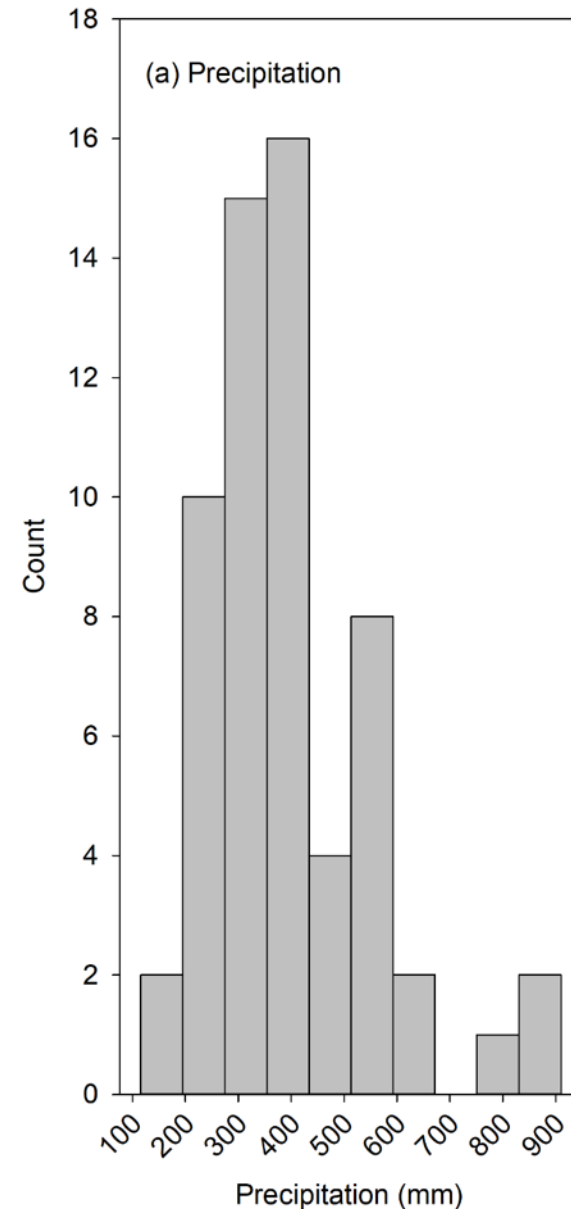
Results Continued

- 20 studies in Asia
 - Sheep were main grazer species
 - 90% of rangeland is estimated to be degraded
 - Restorative studies
 - 15y; mean duration of grazing cessation
- 4 studies in Africa
 - Similar to Asian research objectives
- 17 studies in North America (12 U.S., 5 Canada)
 - Cattle were main grazer species
 - Exploratory enhancement studies
 - 49y; mean duration of ungrazed control plot
 - 36y; duration of grazed plots
- 1 study in Australia
 - Similar to North American research objectives



Results: Environment

- Mean annual precipitation by site was ~390 mm with a range from 116 mm to 910 mm
- Mean annual temperature by site was 7 °C with a range from -2 °C to 21 °C
- Majority of studies occurred at sites where less than 400 mm of annual precipitation fell
- 5 studies occurred at sites receiving more than 600 mm of annual precipitation

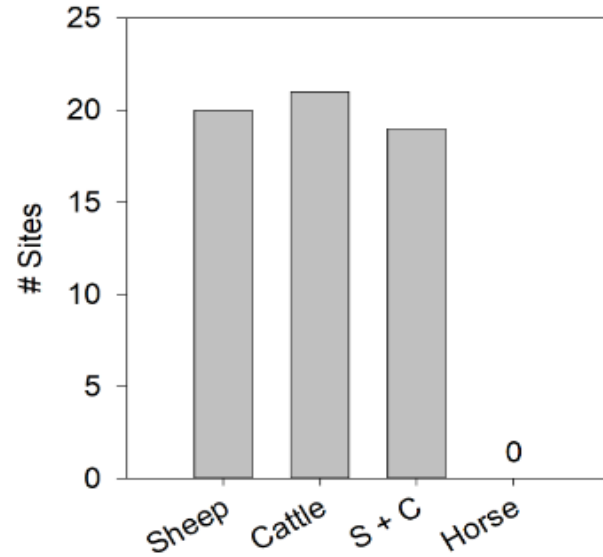


Results: Species and Setting

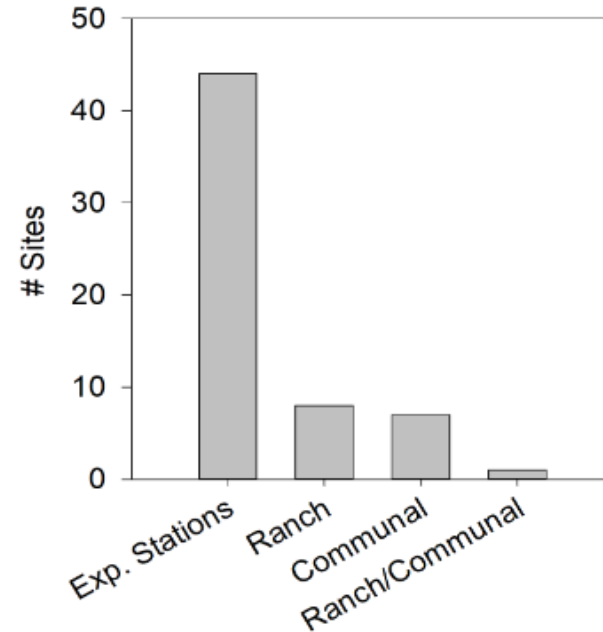
- 21 sites utilized cattle (*Bos* species)
- 20 sites utilized sheep (*Ovis* species)
- 0 sites utilized horses (*Equus* species)
- 19 sites co-grazed
- 8 sites identified as “ranch-scale”
- 44 sites were research facilities
- 7 sites practiced communal grazing



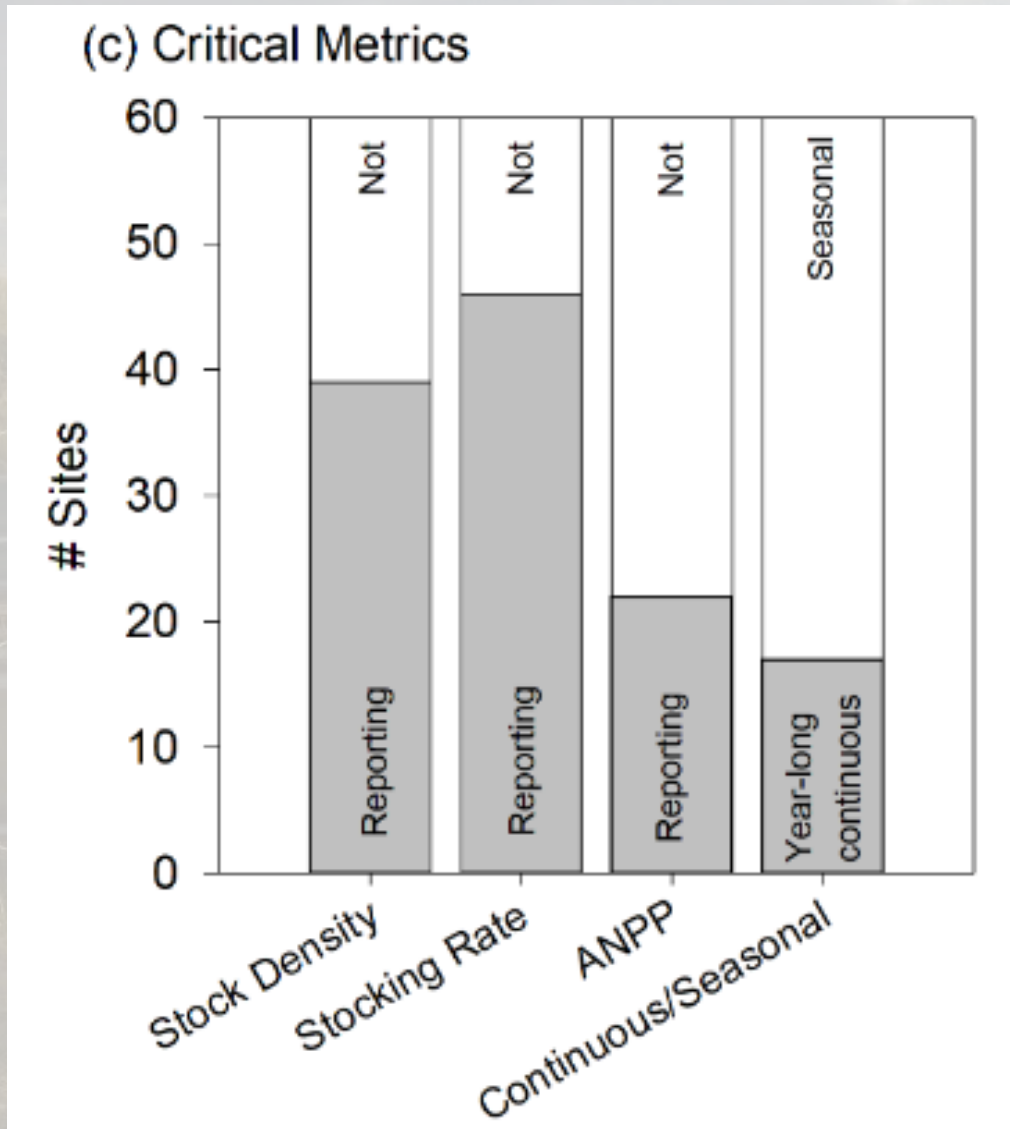
(a) Herbivore species



(b) Study Setting



Results: Critical Grazing Metrics



- 21 sites did not indicate stock density
- 38 sites excluded annual forage production information
- 14 sites failed to report quantitative stocking rate data
- Only 17 sites practiced continuous year-round grazing
- 5 months was the mean of the grazing season
- 4 sites implemented winter grazing

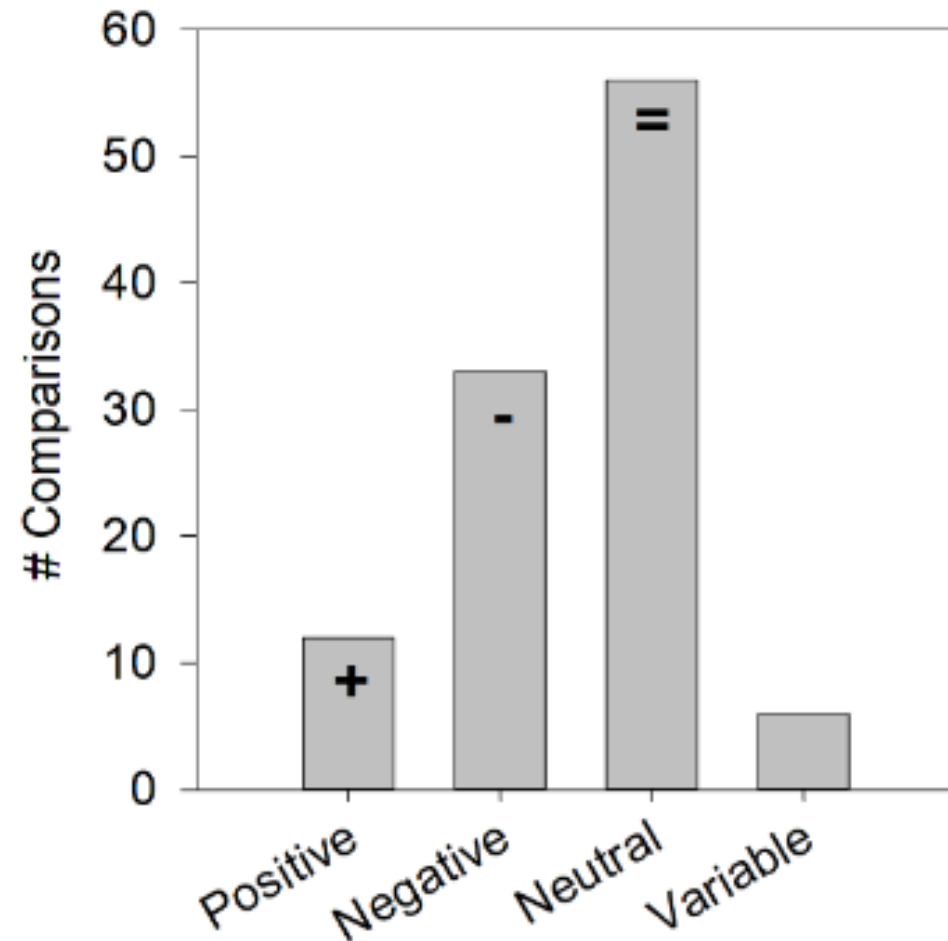
Results: Soil Sampling and Reporting Metrics

- An average of 3 soil depths were sampled ranging from 1 to 9 depths per study
- 11 cm; average of first depth
- 39 cm; average of last depth
- 5 cm to 120 cm was the range of total depth
- All soil types were reported
- 14 studies reported SOC in %
- 12 studies reported SOC in kg/ha
- 16 reported both % and concentration by area
- Only 2 studies indicated that a year one baseline SOM or SOC sample existed

Results: SOM/SOC Responses to Grazing

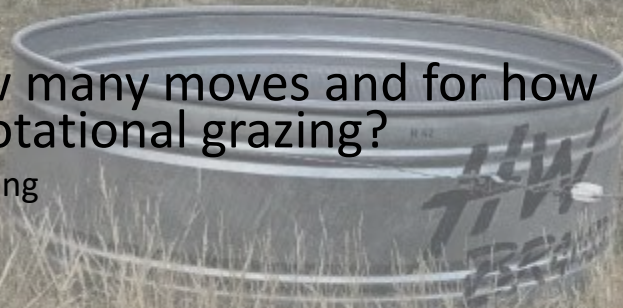
- 12 positive responses
- 33 negative responses
- 56 neutral responses
- 6 variable responses

(d) SOM/SOC Responses to Grazing



Terminology Discrepancies and Interpretation

- Intensity vs. Density
- Stocking Rate vs. Stock Density
- Control or Not Grazed, Enclosure, Exclosure, Rest Grazing
- Continuous- if not 12 months, is it really continuous?
 - Free-grazed or Set-Stocked
- Rotational- how many moves and for how long qualifies rotational grazing?
 - Cell or Mob grazing
- Anecdotal vs. quantitative Stocking Rate description
- Soil Organic Matter vs. Soil Organic Carbon
- Reporting units: Content, concentration, mass, volume, percentage
 - Percent Carbon g/kg vs. Concentration Mg/ha
- Pools of Carbon Terminology
 - Organic or immobile, stable
 - Inorganic or light, labile, active, mobile, mineralizable, available



B3
MRG

Rangeland Carbon and Carbon Pools

- On properly managed rangelands (not overgrazed) ~90% of soil C is stable
- Organic
- Immobile
- Reflects regional climate, plant, and soil interactions
- Resistant to minor disturbances
- Better long term indicator of management
- About 10 % is labile, etc., and largely dependent on soil moisture
- Inorganic
- Mobile
- Fluctuates inter-annually based on moisture
- Less accurate management indicator (heavily influenced by environment)

Carbon Response Discrepancies

- Positive Response
 - C3 to C4
 - Comparative metrics (grazed vs. grazed or grazed vs. ungrazed)
 - Depth
 - Interpretation
- Neutral Response
 - Usually a response of proper management (proper or adaptive stocking).
 - majority of the organic matter in temperate Canadian grasslands is estimated to be >10,000 years old (Seastedt 1995; Henderson et al. 2004)
 - Interpretation
- Negative Response
 - Legacy effect
 - Overgrazing
 - Drought
 - Overstocking
 - Interpretation

Conclusions

- Large variation in research techniques, sampling procedures, grazing terminology, and site characteristics
- Grazing management appears to be flexible in semi-arid rangelands with historically practiced informed grazing (adaptive stocking rates).
- Regional knowledge must be obtained before grazing recommendations are given
- SOM/SOC may not be the product of grazing management, rather informed stocking rates may be the product of SOM/SOC.
- Neutral responses could indicate sustainability based on using the soil and forage resource for livestock production and livelihood without resource base depletion
- Based on the 2010 average publication date, semi-arid rangeland research could be considered in its infancy
- There is an opportunity for more soil health research at the ranch-scale

BOTTOM-UP RANCH-SCALE EVALUATION OF
THE RELATIONSHIP BETWEEN SOIL HEALTH,
FORAGE QUALITY, AND GRAZING CAPACITY IN
A HIGH-ELEVATION RANGELAND



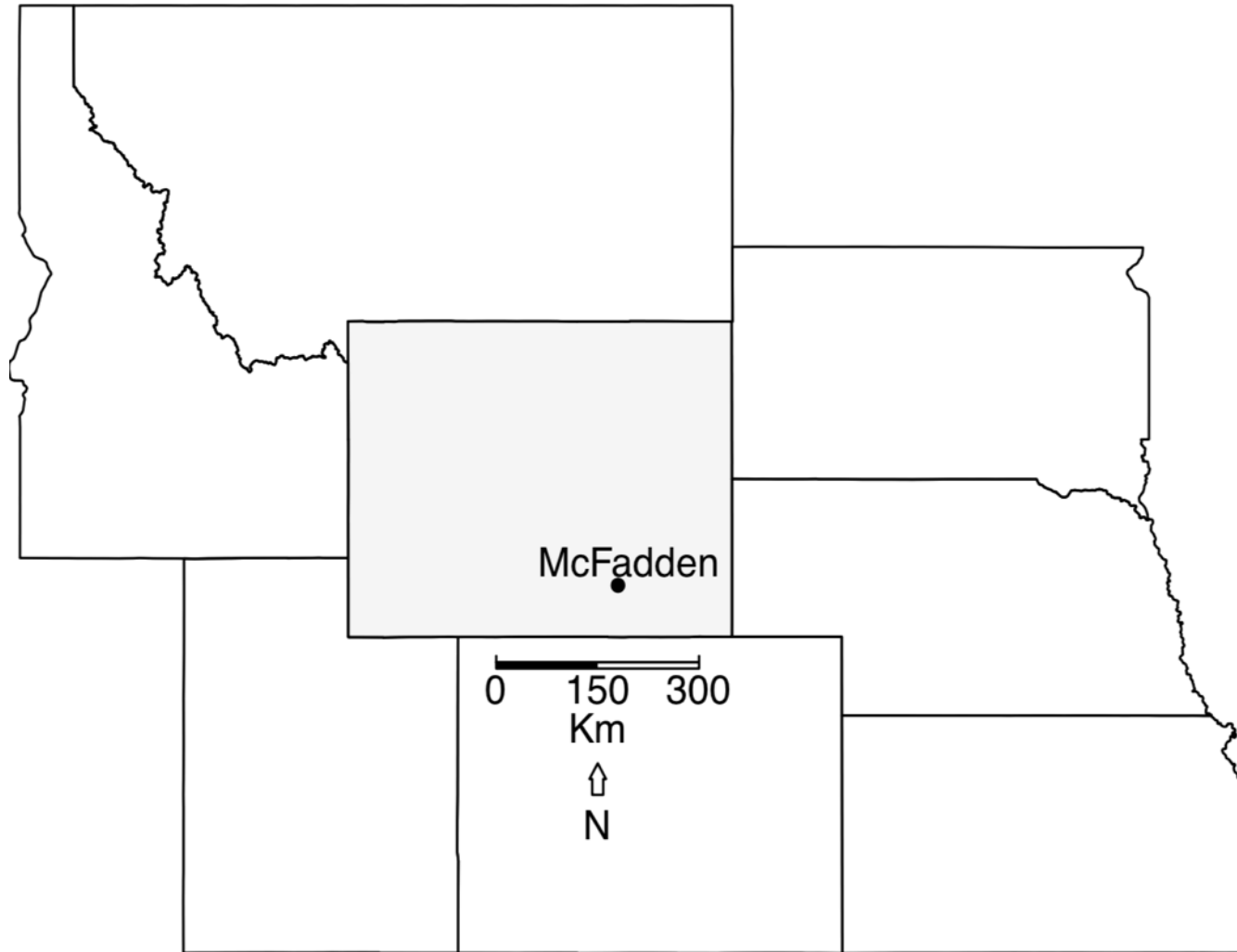
Sims Cattle Company, LLC

Timm Gergeni, Dr. Derek Scasta

tgergeni@uwyo.edu

What We Know About Ranch-Scale Soil Health Research

- When a modified bison rotation was compared to a continuous cattle rotation at light and heavy stocking rates at ranches in South Dakota, increases in litter and forage biomass occurred with rotational grazing, but **similar amounts of soil C** between all grazing strategies were realized (Hillenbrand et al. (2019) .
- At two ranches in Colombia, **SOC increased** after one year in pastures managed with intensive rotational grazing compared to pastures managed with traditional grazing practices (Teutscherova et al. 2020).
- Rotational and continuous management of 3 commercial ranches in north Texas were compared. Rotational grazing resulted in **superior forage production, composition, and greater soil carbon** (Teague et al. 2011).



Location of Sims Ranch in McFadden, Wyoming for evaluating the relationship between soil health, forage quality, and grazing capacity at the ranch-scale in a high elevation steppe study.

Study Site

- Sims Cattle Company, LLC
- McFadden, WY
- MLRA 034A - cool central desertic basins and plateaus
- MAP 10 - 14 inches
- MAT 39 - 45°F with 75 -110 frost-free days



Study Site

- 7,200 to >7,400 feet
- Northern mixed-grass prairie
- Shallow loam
- Cold, Arid Steppe
- Unsuitable for crop production



Forage Species and Production

- Western wheatgrass (*Pascopyrum smithii*) (Rydb.) Á. Löve
- Sandberg bluegrass (*Poa secunda*) J. Presl), bluebunch wheatgrass (*Pseudoroegneria spicata*) (Pursh) Á. Löve ssp. *Spicata*)
- Mutton bluegrass (*Poa fendleriana*) (Steud.) Vasey)
- Needle-and-thread (*Hesperostipa comata*) (Trin. & Rupr.) Barkworth)
- Dry year: 700 lbs. per acre
- Average year: 900 lbs. per acre
- Wet year: 1,200 lbs. per acre

-NRCS 2004

Research Questions

- What is the relationship between soil or forage response variables and Animal Days per Acre?
- Does Organic Matter/Organic C predict AD/A?
- Does Crude Protein predict AD/A?

What does Animal day per acre mean?

- Animal day = lbs. of forage needed by 1 cow/calf pair (~26 lbs. of forage per day for a 1,000 lb. cow)
- At Sims Ranch: Average cow weight is 1,155 lbs. ($0.026 * 1,155 \text{ lbs.} = 30 \text{ lbs.}$ of grass per day for a Sim's cow)
- Example: If 1 Sims acre produces 150 lbs. of grass it would equate to 5 AD/A

Background & Study Information

- Ranch managers have recorded pasture-scale grazing data since 1989.
- Specifically, Animal Days per Acre or AD/A = carrying capacity of forage resources within each pasture.
- 3 herds of ~300 crossbred Angus cows, implementing grazing-deferment, with 50% or less annual forage utilization across 140 pastures.
- 11 upland native pastures
- 3 permanent exclosures (est. 1990's).
- AD/A range from 4 – 5.4

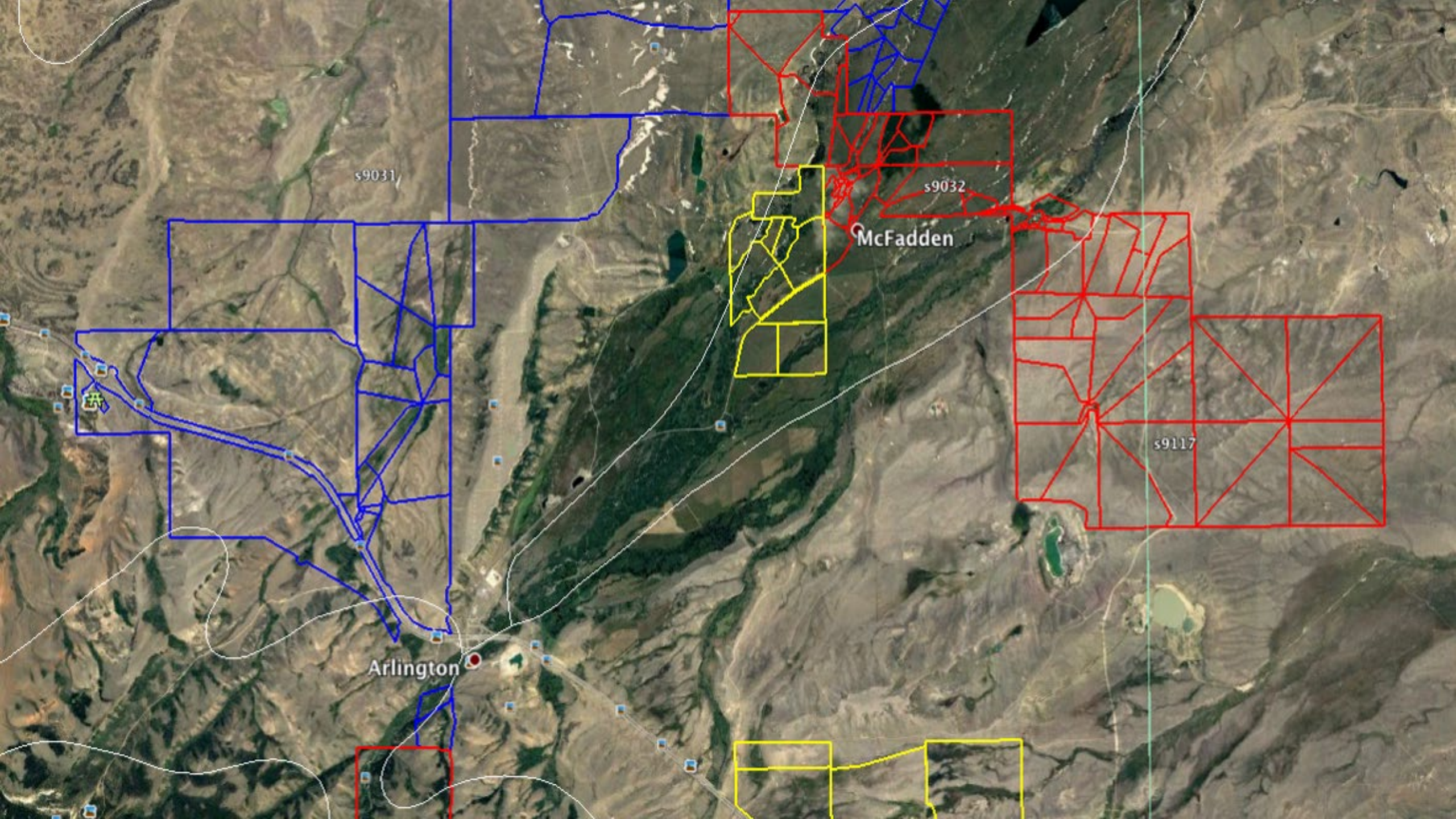
- *AD/A were stratified low, medium, high and none into Animal Day Pasture Categories as follows :

- Low = 4.0 – 4.2 AD/A ($n=3$)
- Medium = 4.5 – 4.8 AD/A ($n=5$)
- High = 5.0 – 5.4 AD/A ($n=3$)
- None or exclosures ($n=3$)



Soil and Forage Sampling Methods (10 June 2017 – 13 June 2017)

- Three largest soil series per pasture were sampled 4 times within each pasture to 10 cm, fifty feet inside soil series boundary, and catena was accounted for.
- Samples were then pooled by pasture and weighted.
- 30 to 50 tillers of western wheatgrass (*Pascopyrum smithii*) (Rydb.) Á. Löve) were clipped in each pasture at soil sampling sites.



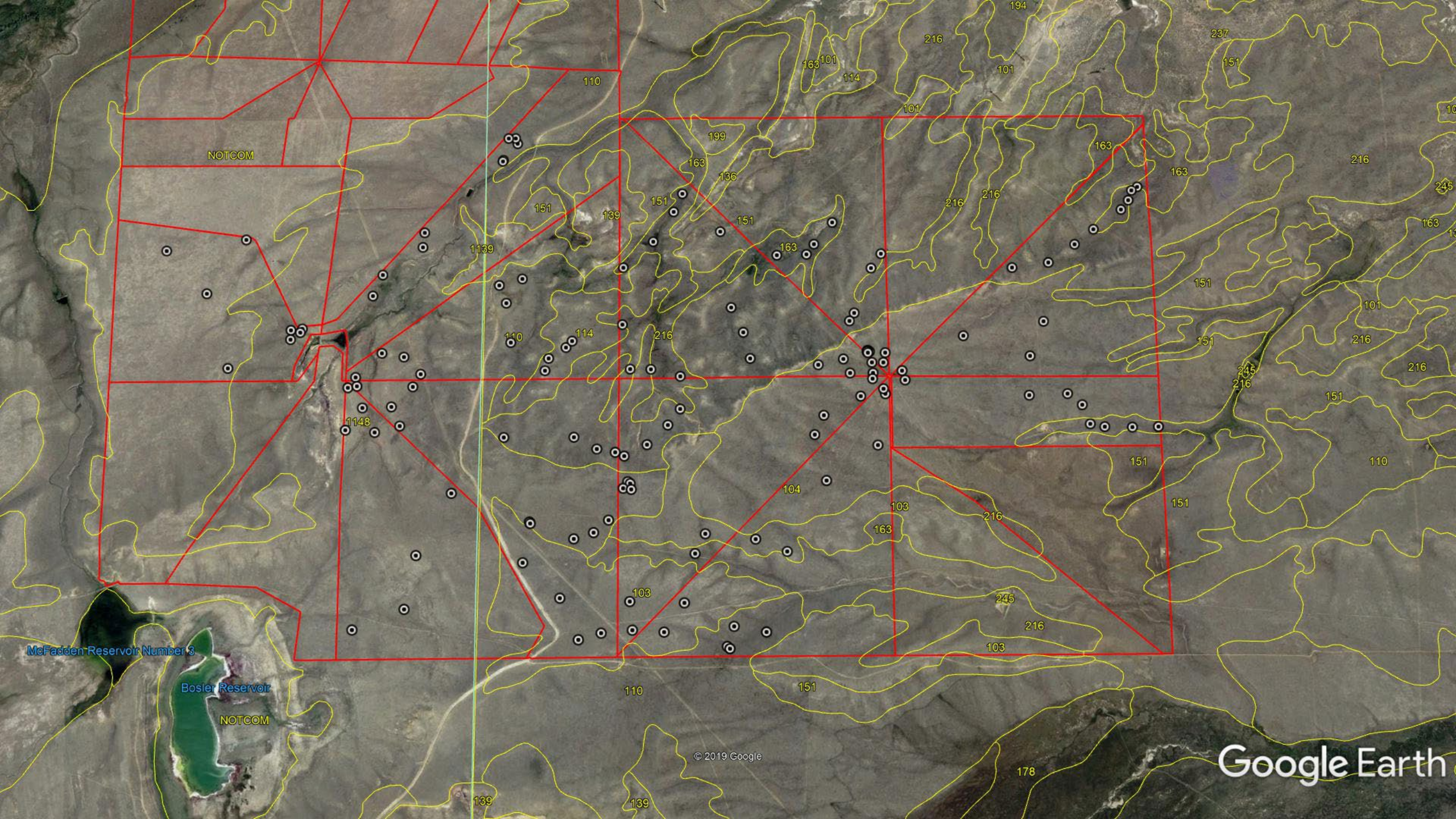
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McFadden

Arlington



NOTCOM

McAdams Reservoir Number 3

Bosler Reservoir

NOTCOM

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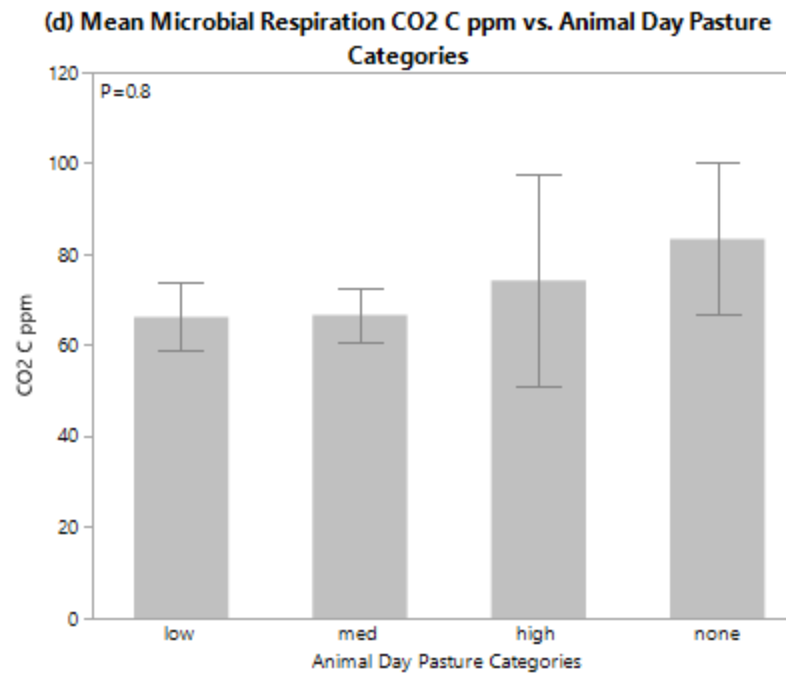
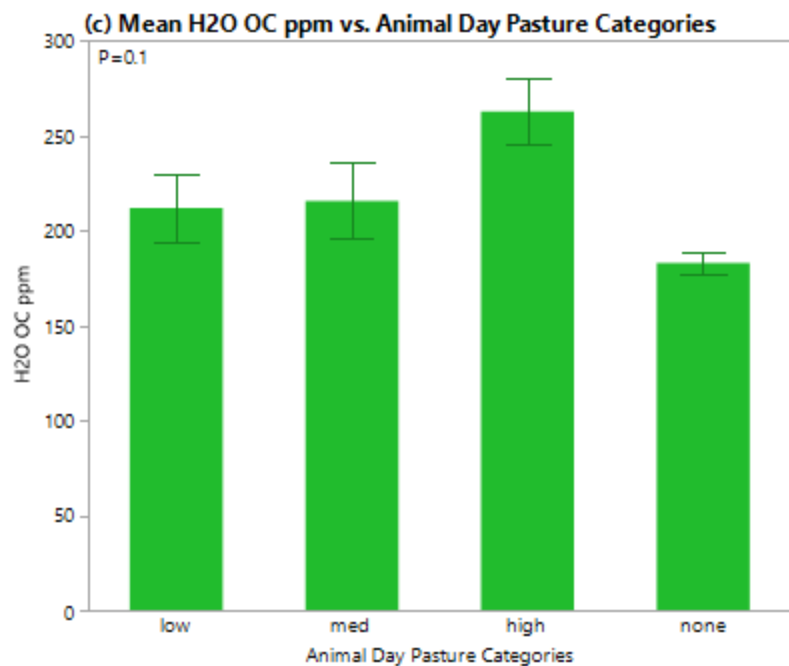
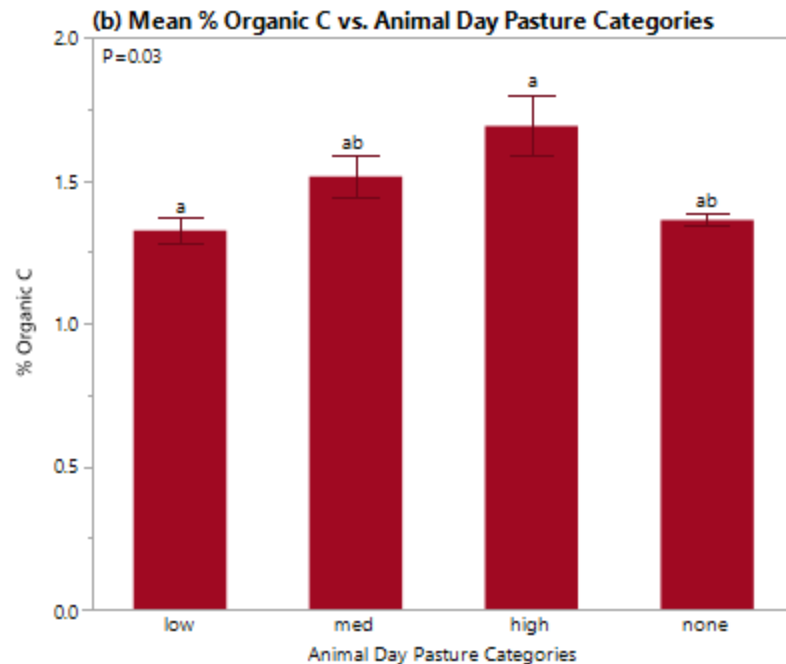
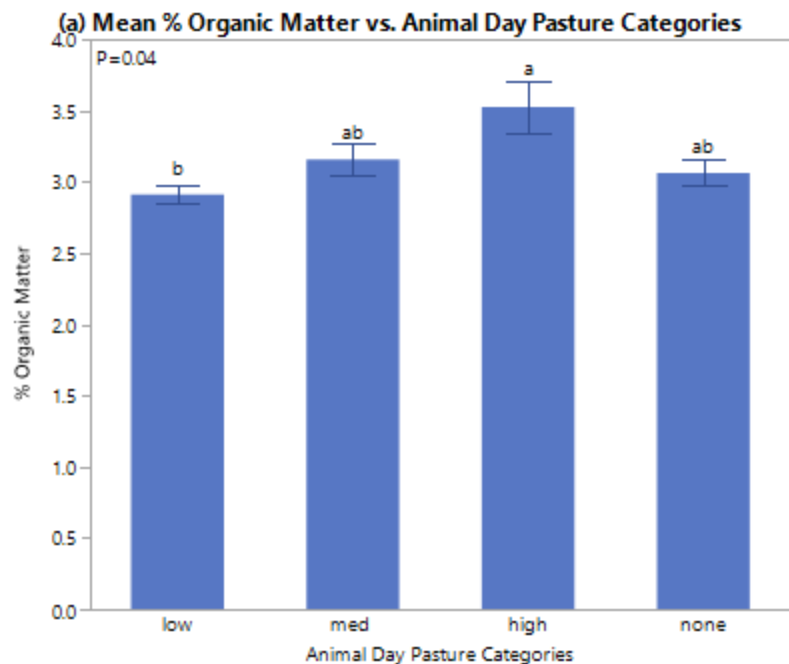
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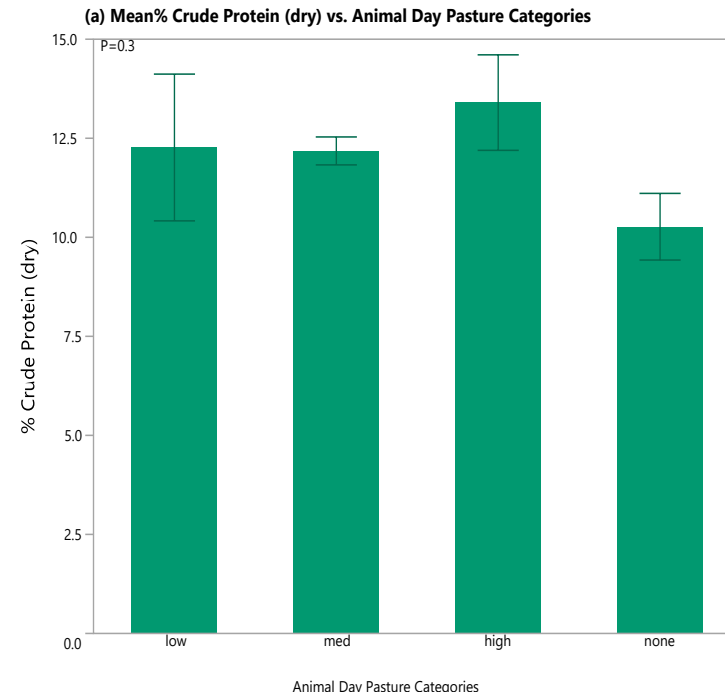
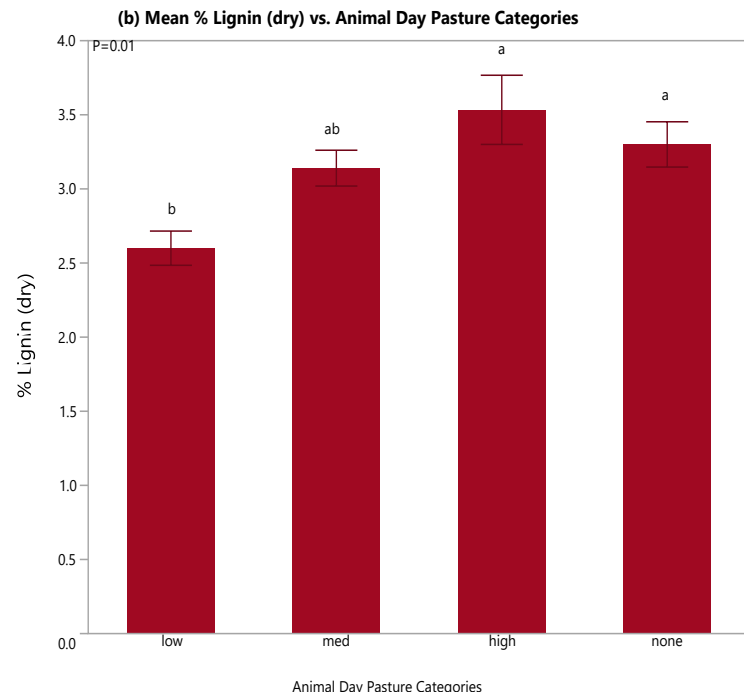
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Statistical Analyses

- Univariate one-way ANOVA (*SAS JMP Pro 14*)
- Linear regression (*SAS JMP Pro 14*)
- Multivariate PCA and RDA (*Canoco 5*) – *not presented*





Why is %OM useful for Ranchers?

Foundation for nutrient cycling that supports rangeland plants and animals.

Potential indicator of carrying capacity.

Inexpensive analysis.

Stable, good indicator of management effect over time (illustrated in next study)

Contribution: organic matter positively influences all properties of soil health.

Comprehensive

Practical



Conclusions

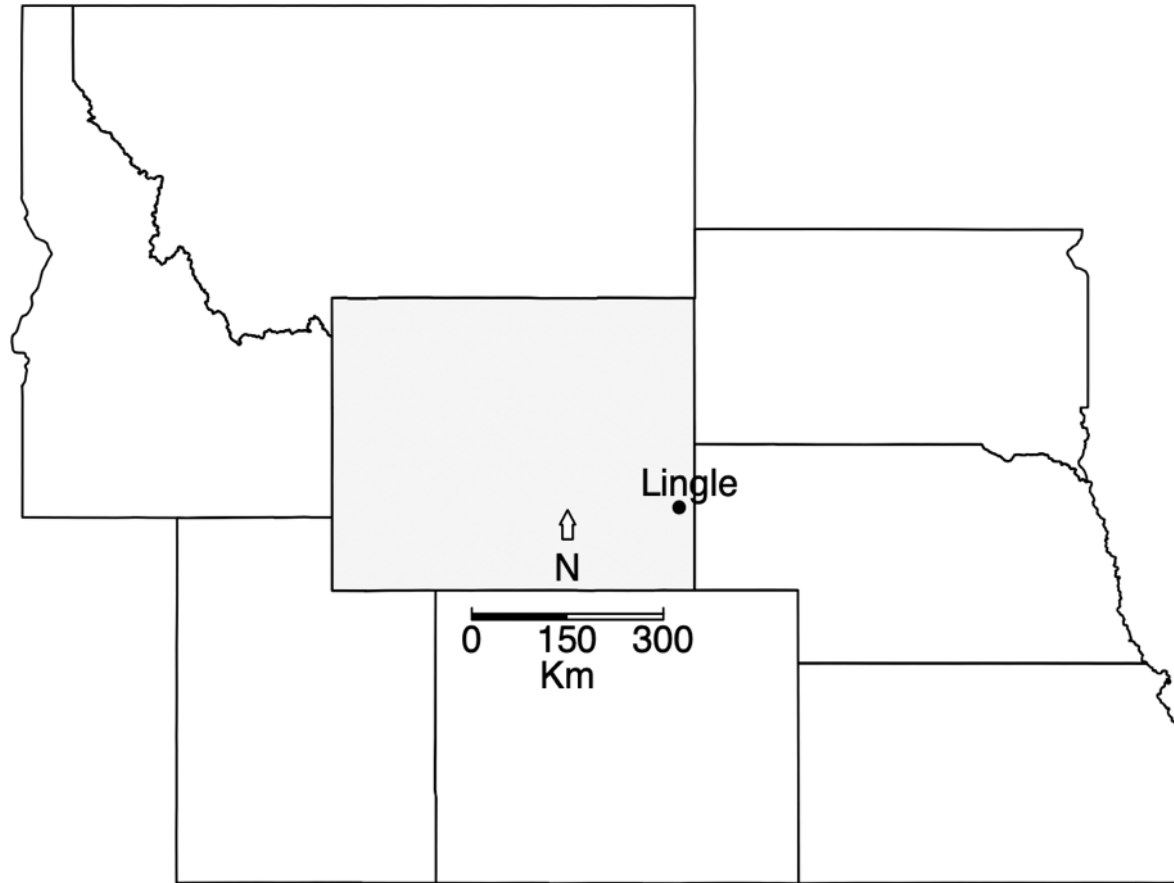
- Certain soil health metrics may be useful indicators of greater or lesser animal days per acre. Such as SOM or SOC.
- SOM/SOC may not be the product of grazing management, rather informed stocking rates may be the product of SOM/SOC.
- Ultimately, baseline soil analyses must be catalogued for most accurate temporal assessment of grazing effect (which we now have for Sims Ranch).
- Producers need data to draw conclusions, not anecdotal information.
- Future resampling (30 years?) may detect if grazing is influencing AD/A or if AD/A is just a reflection of inherent soil properties and environment. We can now accomplish this. Only then can we give herd management recommendations.

TOP-DOWN EFFECTS OF GRAZING DENSITY ON SOIL HEALTH IN A NORTHERN MIXED GRASS PRAIRIE



What We Know About Multi-Paddock Systems and Grazing Density

- A multitude of grazing studies have resulted in claims that rotation, stocking rate, **density**, or **grazing exclusion** may **enhance soil properties** (Teague et al. 2011; 2013; 2017; Steffens et al. 2011; Weismeier et al. 2012; Russell et al. 2013; Wang et al. 2017^a; Chen and Tang 2016; Zaralis and Padel 2018), but **with changes to forage species functional groups** (Frank et al. 1995; Reeder and Schuman 2002; Ingram et al. 2008; Wang et al. 2018; and others).
- Direct chemical inputs via fecal matter and urine with increasing grazing densities enhanced nitrogen cycling, as well as phosphorous and potassium levels (Kohandel et al. 2009; Zarekia et al. 2012).
- Higher stocking density and rotation allows producers to optimize cattle movements and determine time and frequency of grazing, potentially limiting selectivity and preventing repeated grazing of preferred plants (Bailey and Brown 2011).
- Teague et al. (2011) and Zaralis and Padel (2018) found that high density rotational grazing increased organic matter.
- Organic matter percentage, water infiltration, and fertility, were negatively influenced at higher rates of trampling, while the effects on vegetation was species dependent (Ferrero 1991).
- Teague et al. (2013; 2015) reported multi-paddock grazing systems are beneficial to plant and animal production systems.
- Relative to grazing regime, Briske et al. (2008), Chan et al. (2010), Franzluebbbers et al. (2019), and Schatz et al. (2020) all have reported no difference between rotationally grazed and continuously grazed pastures.
- Teutscherova et al. (2020) reported SOC increases after one year in pastures managed with intensive rotational grazing compared to pastures managed with traditional grazing practices.
- What is unclear is how grazing management may or may not improve soil health and subsequent forage features of rangelands and the superiority of one grazing system over another is context specific relative to the overall goals of the producer (Pavlu et al. 2006; Briske et al. 2008).



Location of the University of Wyoming's James C. Hageman Sustainable Agricultural Research and Extension Center (SAREC) facility in Lingle, Wyoming used for 2017-2019 grazing intensity and soil health experiment.

Study Site

University of Wyoming's
Sustainable Agriculture
Research Extension Center
(SAREC) near Lingle,
Wyoming

MLRA 67A- central high
plains north

MAP 15-17 inches

MAT 51-54°F



Study Site

~4,444 feet

northern mixed
grass prairie

Deep well-
drained Mitchell
loam

Suitable for crop
production



Forage Species

- Western wheatgrass (*Pascopyrum smithii*) (Rydb.)
Á. Löve)
 - Needle-and-thread (*Hesperostipa comata*) (Trin. & Rupr.) Barkworth)
 - Blue grama (*Bouteloua gracilis*) (Wild. Ex Kunth) Lag. Ex Griffiths).
- Dry year: 1,000 lbs. per acre
 - Average year: 1,500 lbs. per acre
 - Wet year: 2,000 lbs. per acre

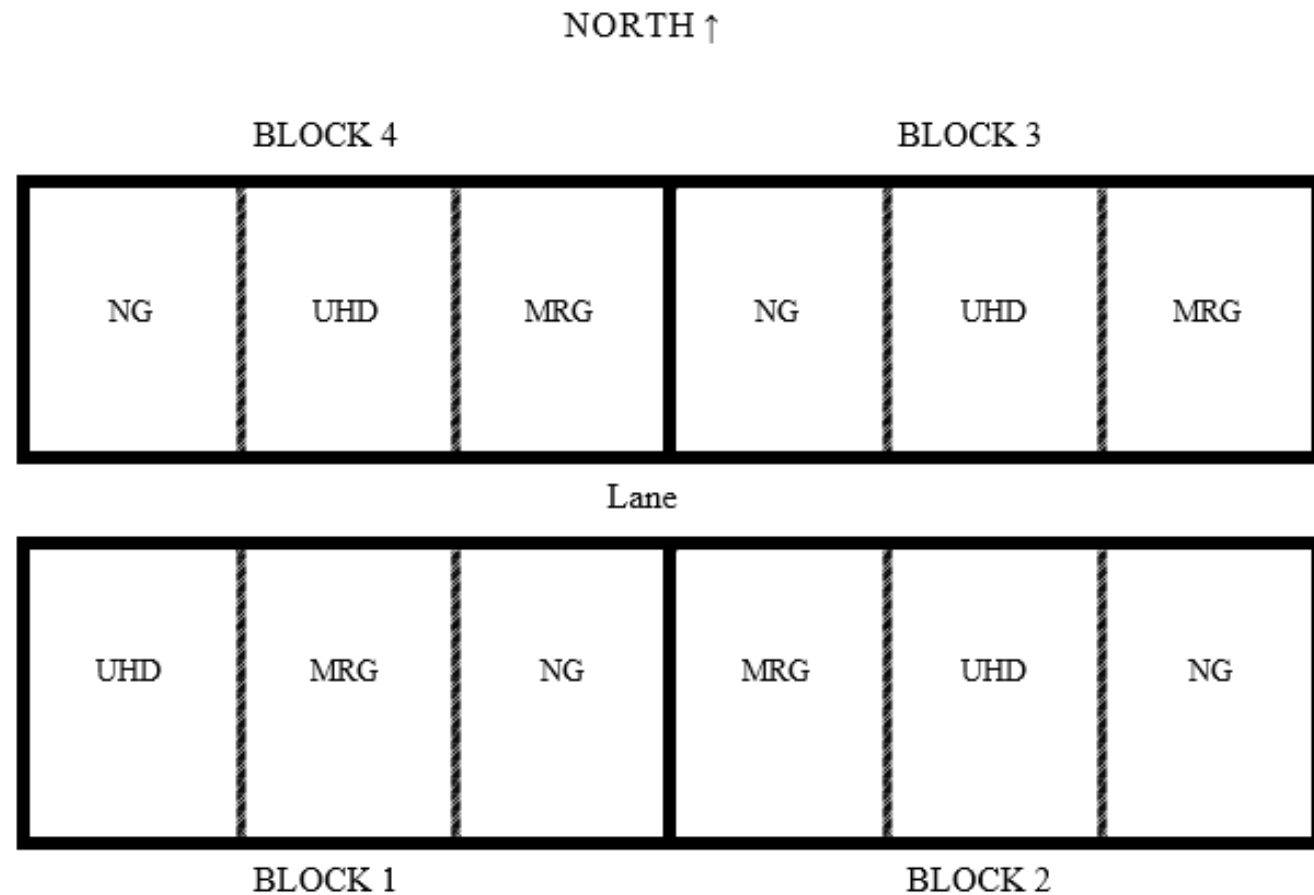
-NRCS 2001

General study area map showing the remnant northern mixed grass prairie relic embedded within an introduced forage pasture



Design

- 12- one acre paddocks
- Randomized complete block design (RCBD) with 3 grazing treatments
- Replicated 4 times (i.e., blocks) for a sample size (n) = 12 total paddocks



NG, MRG, and UHD treatments



NG = 0 lbs. of cattle per acre



MRG = 4,800 lbs. of cattle per acre



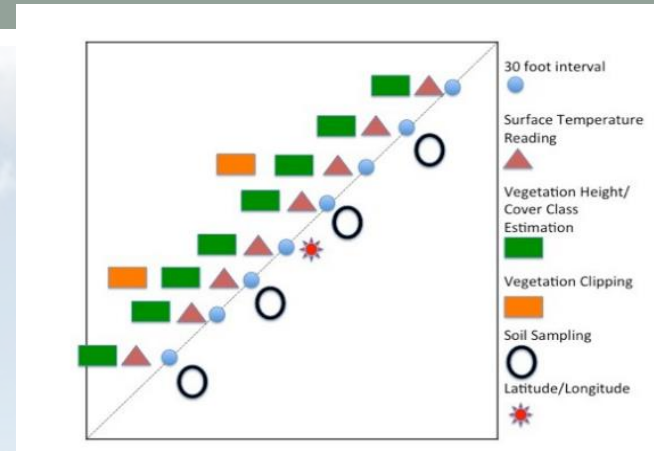
UHD = 60,500 lbs. of cattle per acre



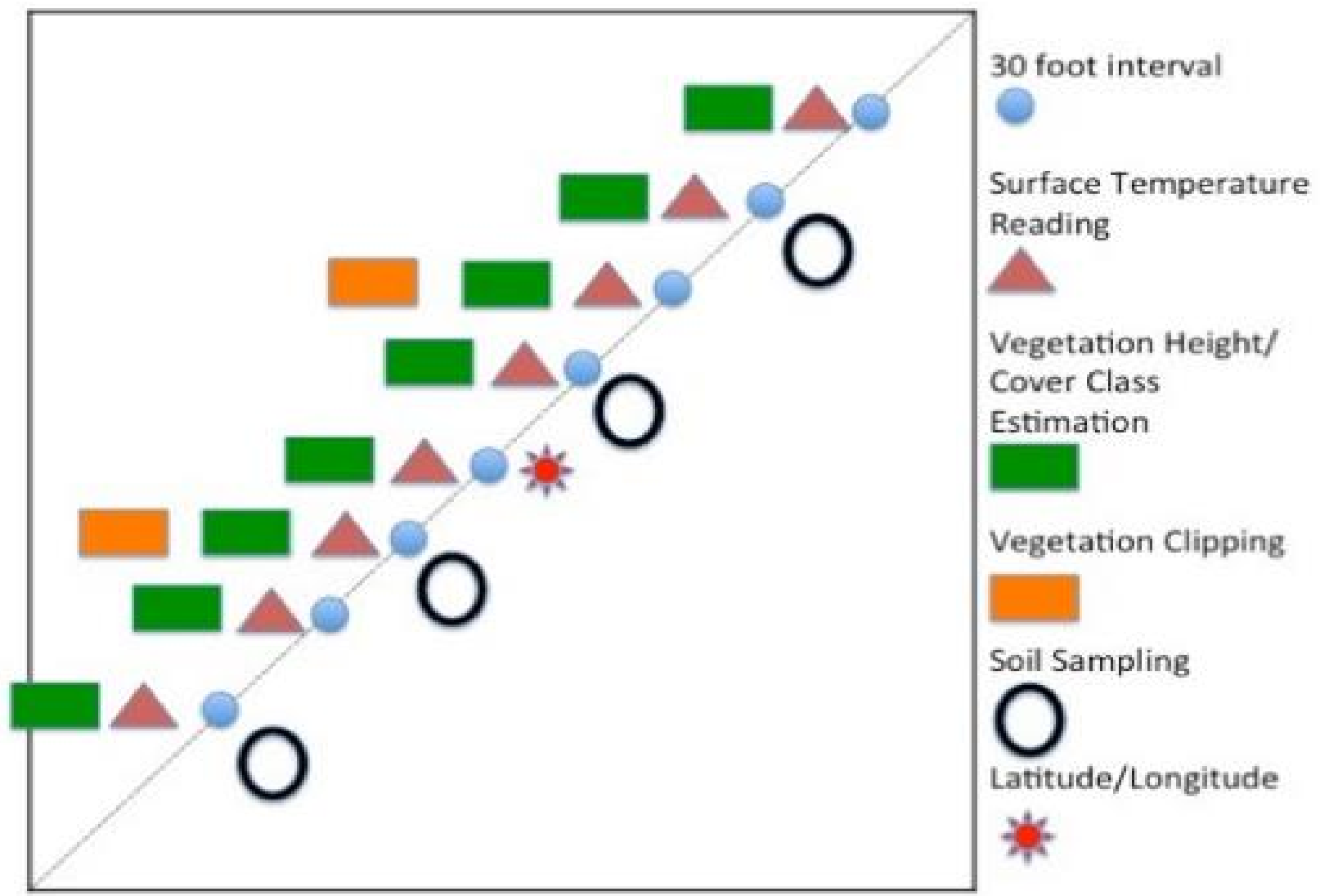
Research Questions

- First, will grazing density, as applied with ultra-high density rotational grazing (UHD), moderate density rotational grazing (MRG), or grazing exclusion (NG), alter soil health properties in a northern mixed grass prairie within a 3 year timeframe?
- Second, if soil health properties are altered, what is the direction (negative or positive) and magnitude of the changes relative to the 3 different grazing management strategies?
- Third, will grazing-induced soil health alterations be expressed by plant functional group and ground cover feedbacks?

Vegetation and Soils Sampling

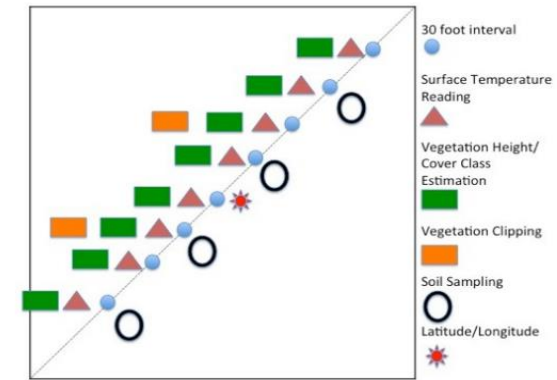


- A transect stretching from northeast to southwest along the long axis of each paddock, was established to collect soil and vegetation data.
- Baseline soils and vegetation data were collected prior to the establishment of grazing treatments June 24th and 25th, 2017.
- Pre-grazing *forage biomass, *forage height, **plant functional groups, and **ground cover classes data were collected annually (*2017-2020; **2017-2019).
- Post-grazing relative soil line temperature and forage height measurements were collected 2017-2019.
- Post-grazing soil health sampling occurred 1 week and 6 weeks post-grazing on July 11th and August 23rd 2019.

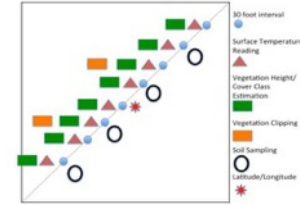


Soil Sampling Methods

- Depth of 10cm
- Samples were taken at 60, 120, 180, and 240 feet along the permanent transect stretching from northeast to southwest in each paddock.
- The 4 samples per paddock were pooled into a single paddock composite sample and immediately placed in a cooler on ice until delivery to the laboratory.
- June 26, 2017, July 12, 2019 and August 24, 2019 all soil samples were dropped off at Ward Laboratories in Kearney, Nebraska for biological and soil nutrient analyses.



Vegetation Sampling



- 8 vegetation visual obstruction readings using a modified Robel Pole at 30, 60, 90, 120, 150, 180, 210, and 240 feet with observations at each point from each of the four cardinal directions (north, south, east, and west).
- The mean height of the four readings from each point was then calculated and recorded.
- Herbaceous biomass was clipped at 90 feet and 180 feet using a 20 x 50 cm quadrat.
- Herbaceous biomass samples were then dried at 60C° for 48 hours in a forced air oven and weighed.
- The Daubenmire method was used for plant functional groups and ground cover estimates at the same 30 foot intervals as visual obstruction readings.

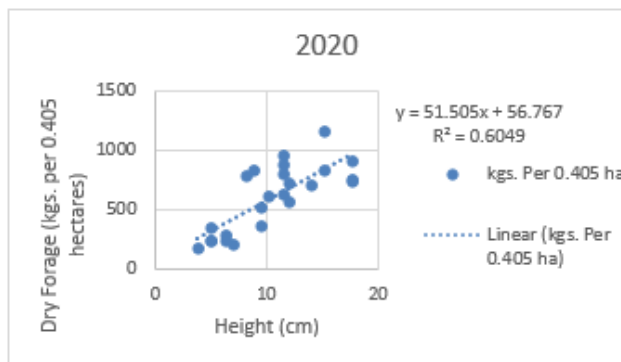
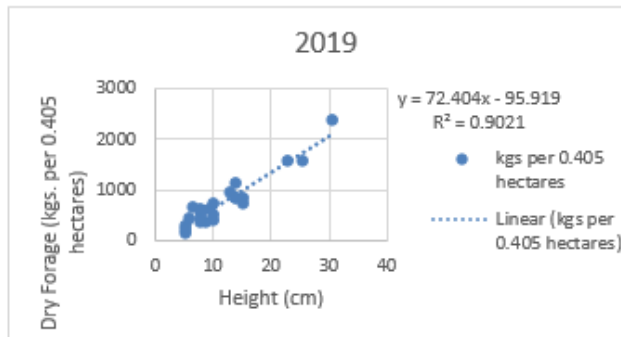
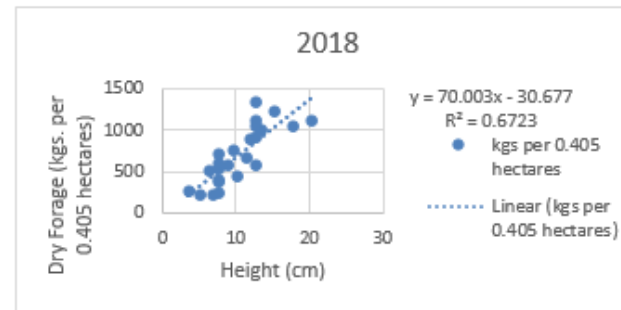
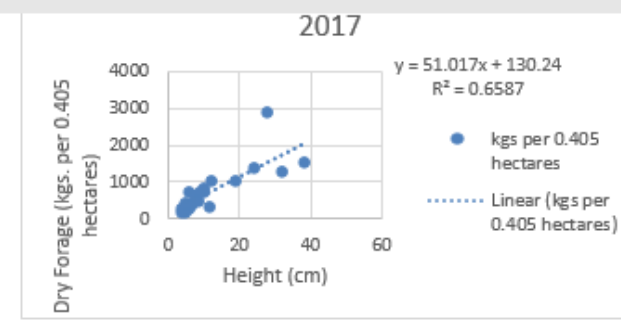
Forage Measurements

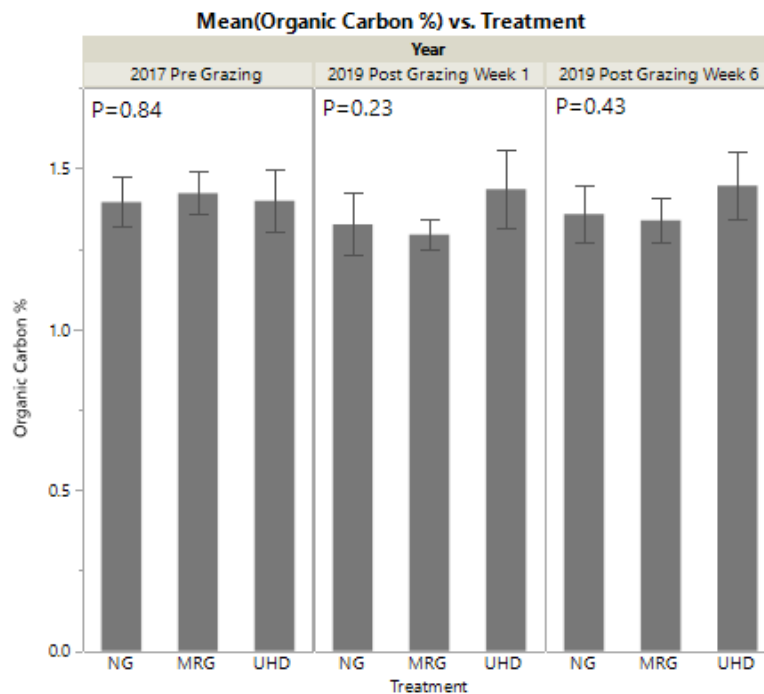
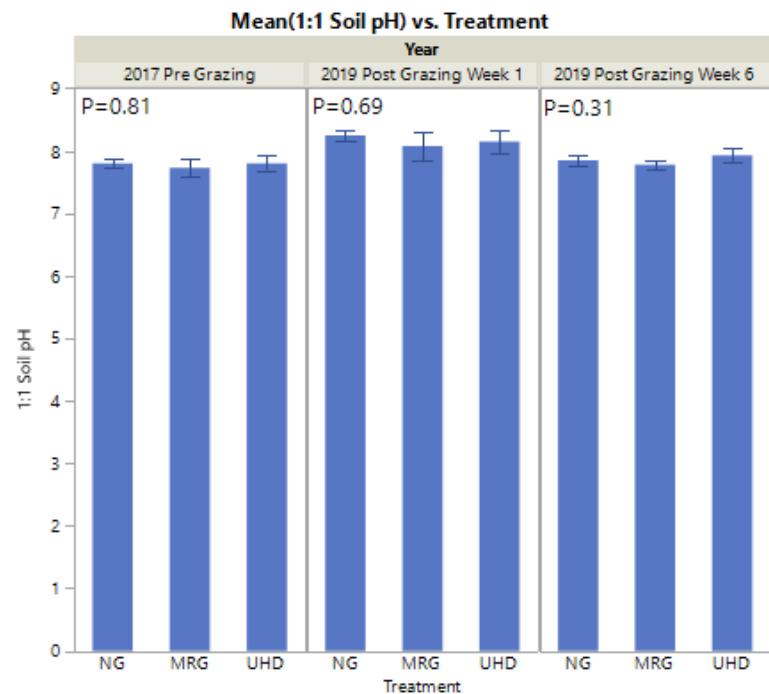
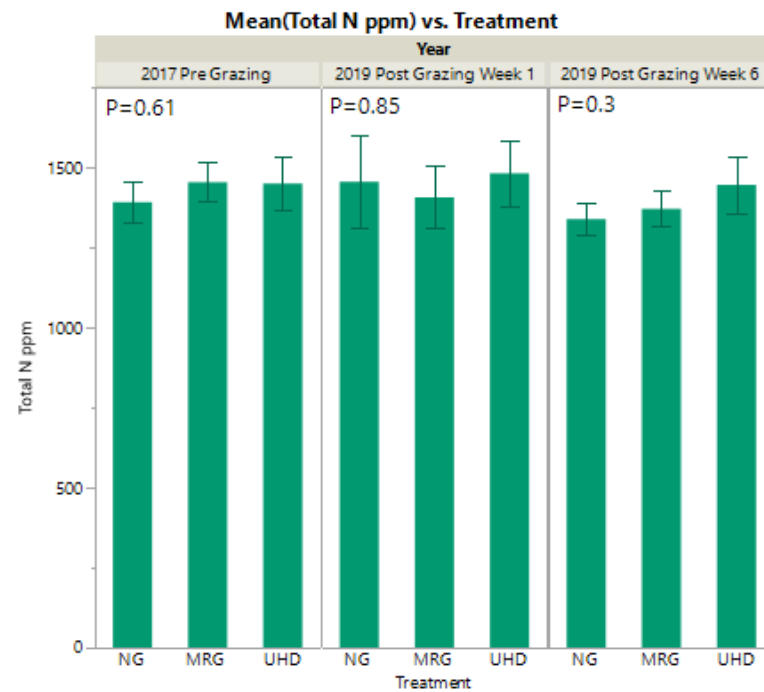
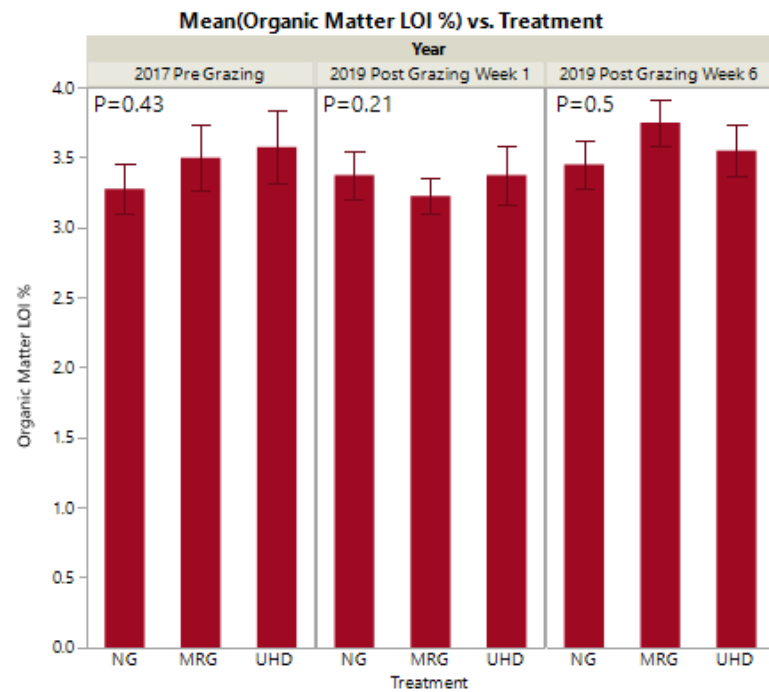
- Biomass
- Height
- Plant functional groups
- Ground cover classes

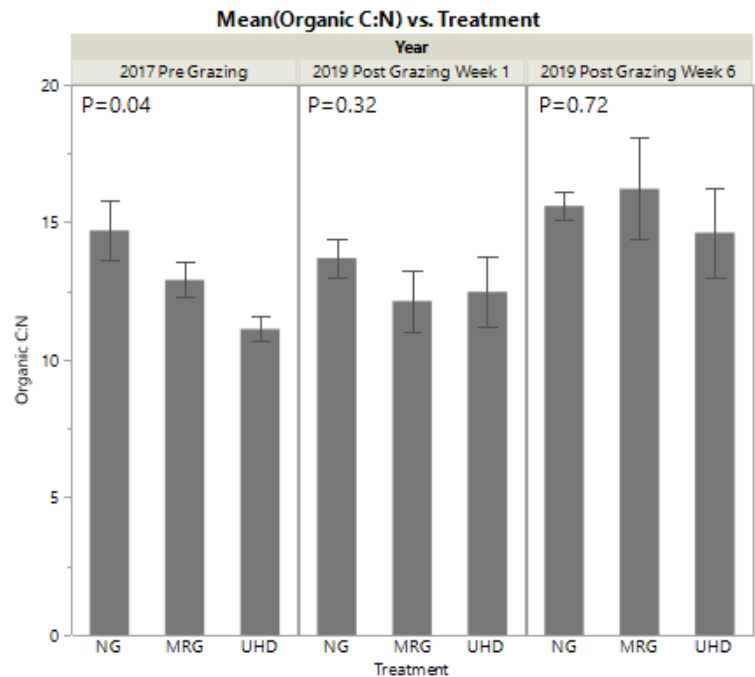
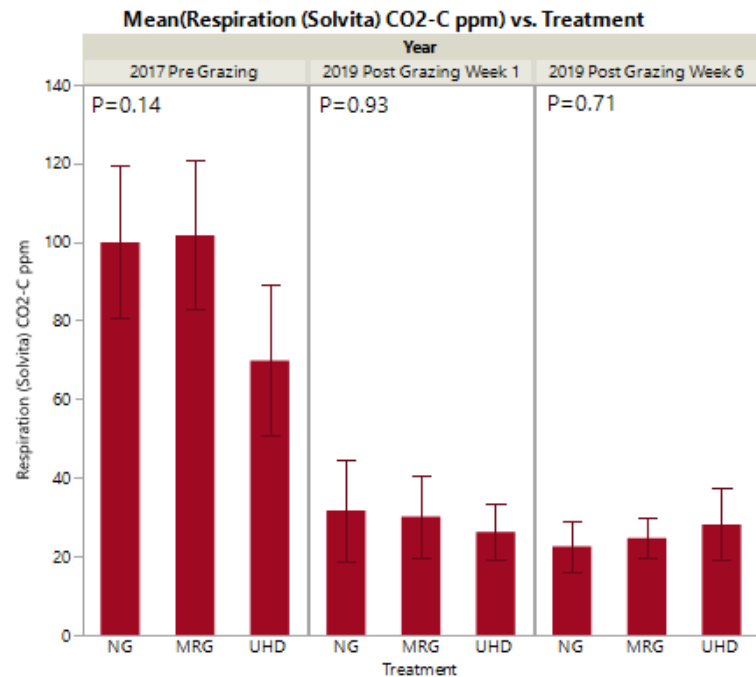
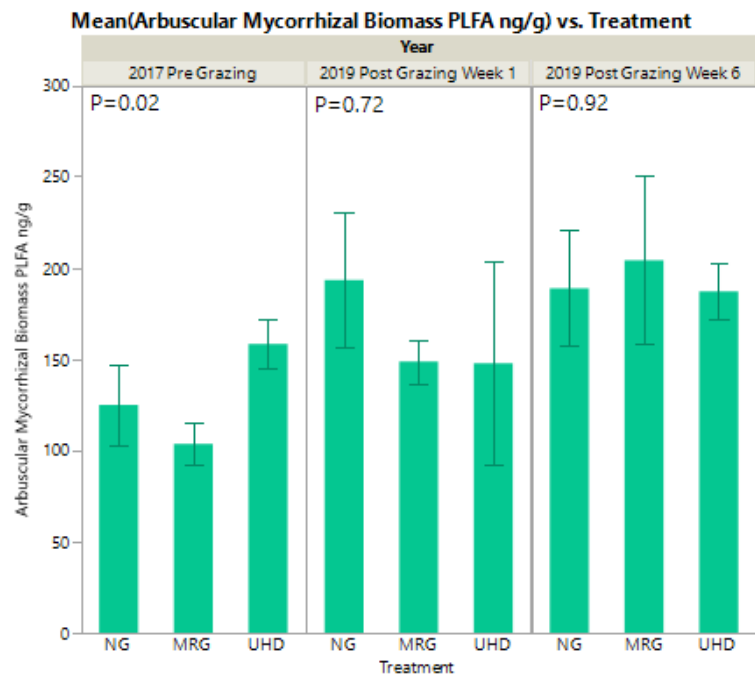
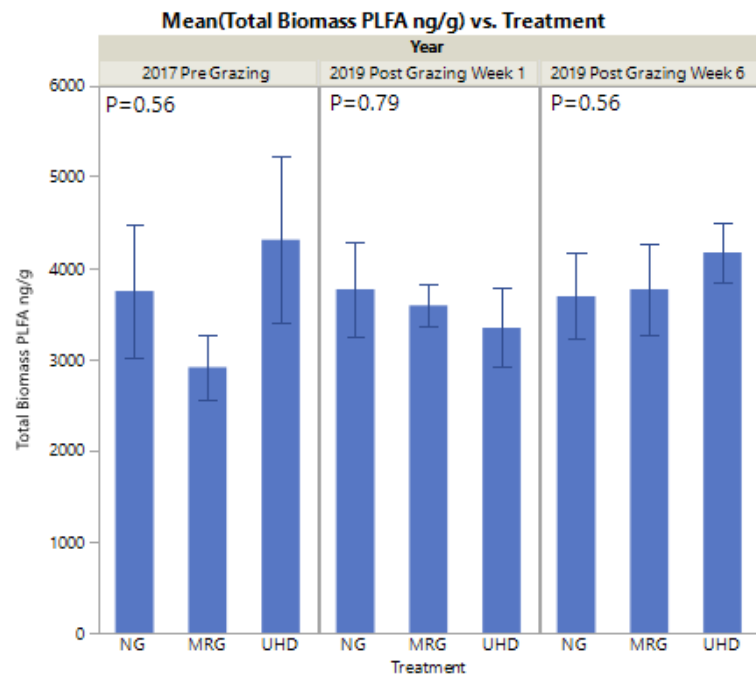


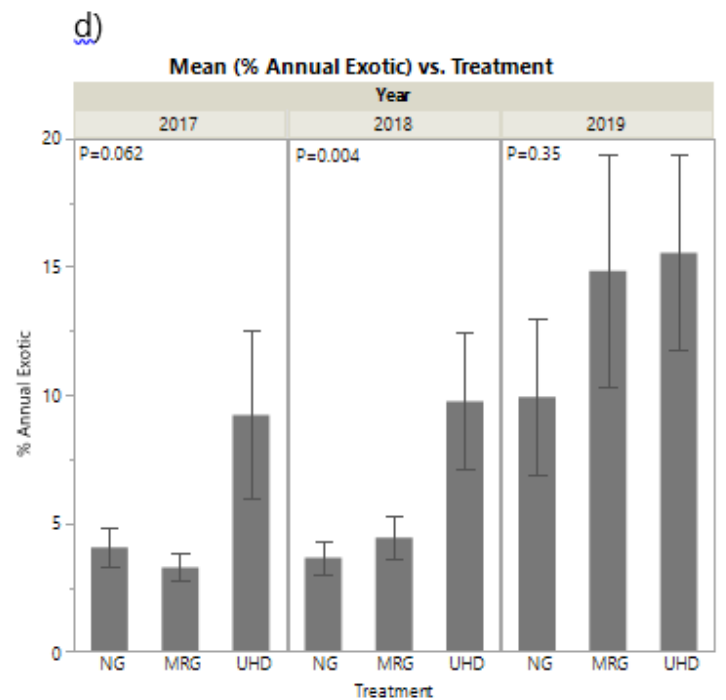
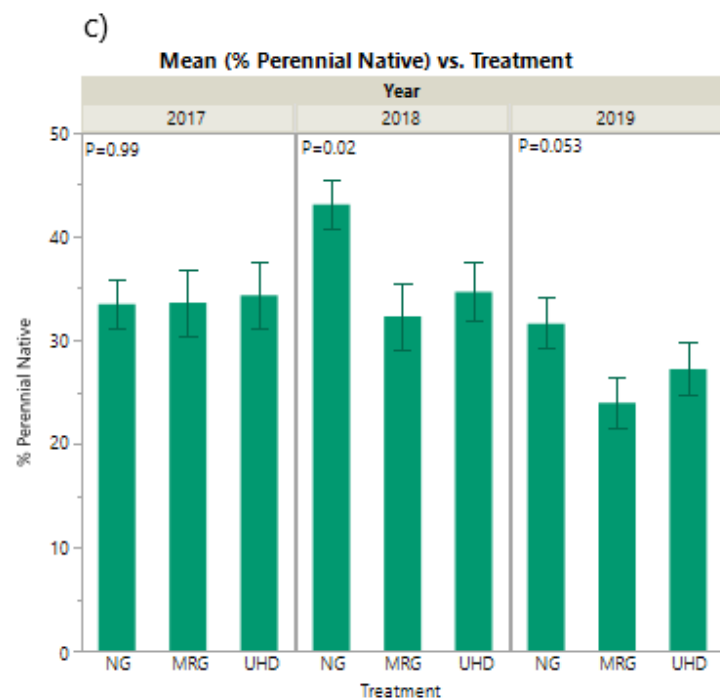
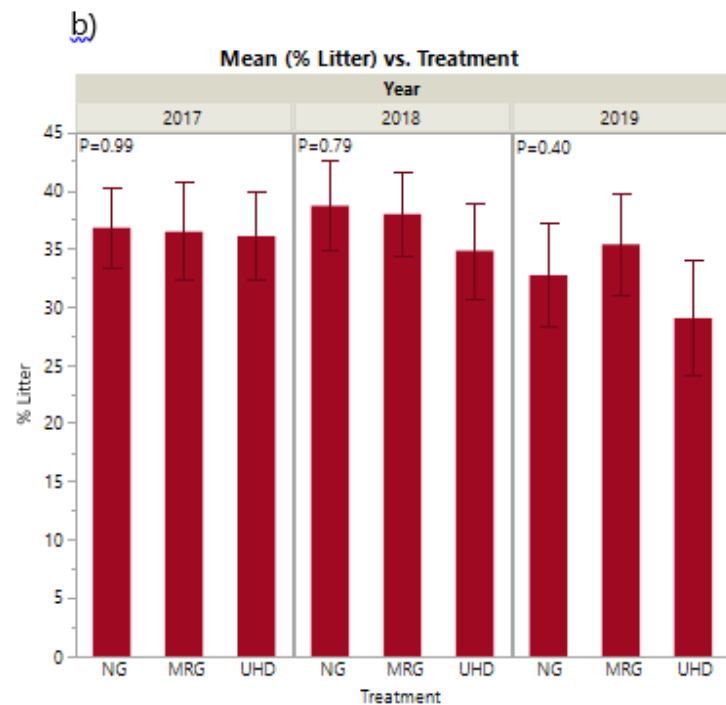
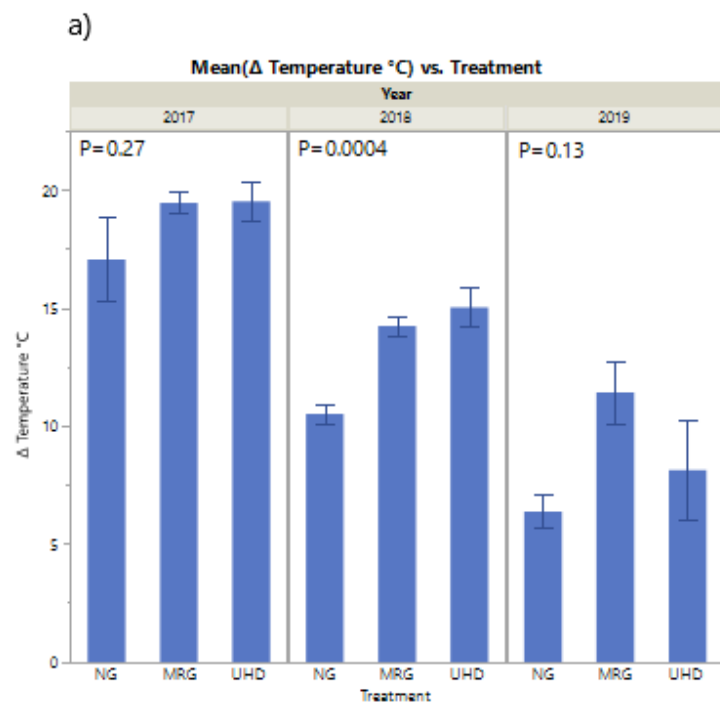
Determining Time in Paddock

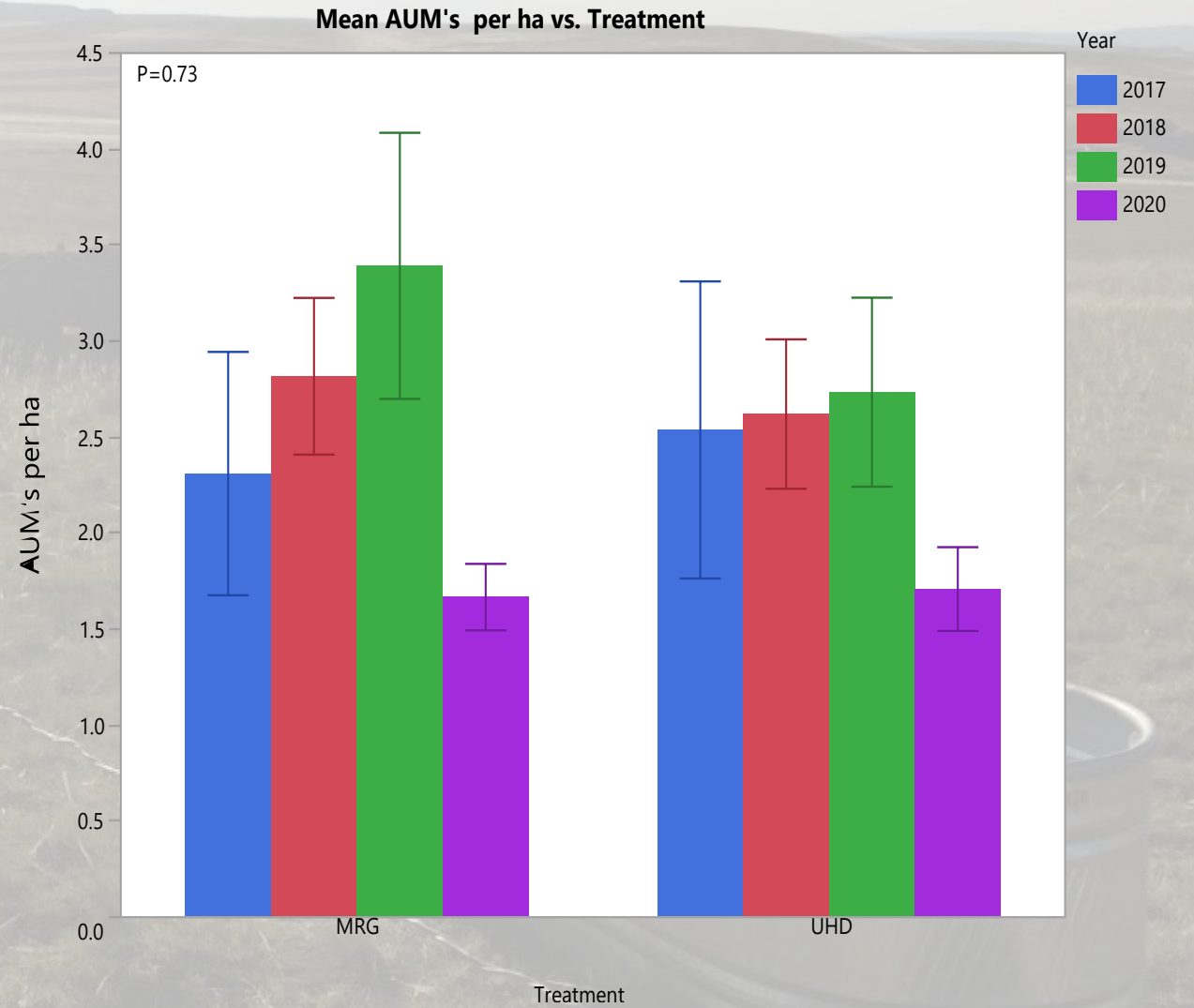
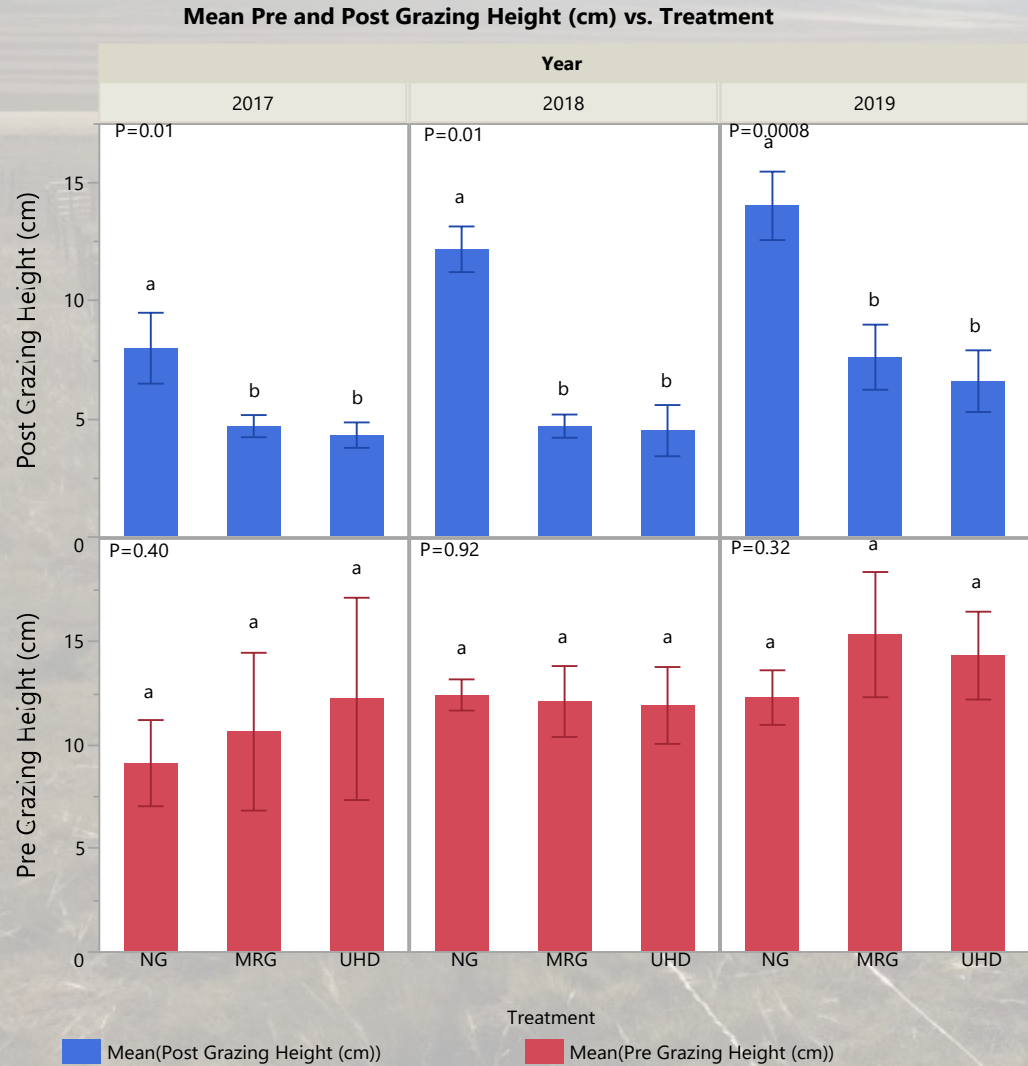
- We coupled the points where herbaceous biomass and vegetation visual obstruction were both measured to develop a predictive linear regression equation using vegetation visual obstruction (x) to predict herbaceous biomass (y) across each paddock











Conclusions:

- Very little treatment effect was detected among any of the response variables.
- It appears that from 2017-2019 herd density has little effect on soil or forage variables at similar forage utilization and stocking rates.
- Neutral responses could indicate sustainability based on using the soil and forage resource for livestock production and livelihood without resource base depletion.
- Because soil properties evolve slowly in cold arid steppes, longer term studies are necessary (Eyles et al. 2015; Liebig et al. 2006).
- This and other studies must be continued across multiple geographic regions in order to catalogue useful grazing information for regional producers (Abdalla et al. 2017).
- Rangeland sampling protocols must be established and understood before accurate assumptions can be determined.

Thank You !



- Dr. Derek Scasta
- Dr. John Tanaka
- Dr. Kristie Maczko
- Dr. Linda van Diepen
- Dr. Pete Stahl
- Dr. Steve Paisley

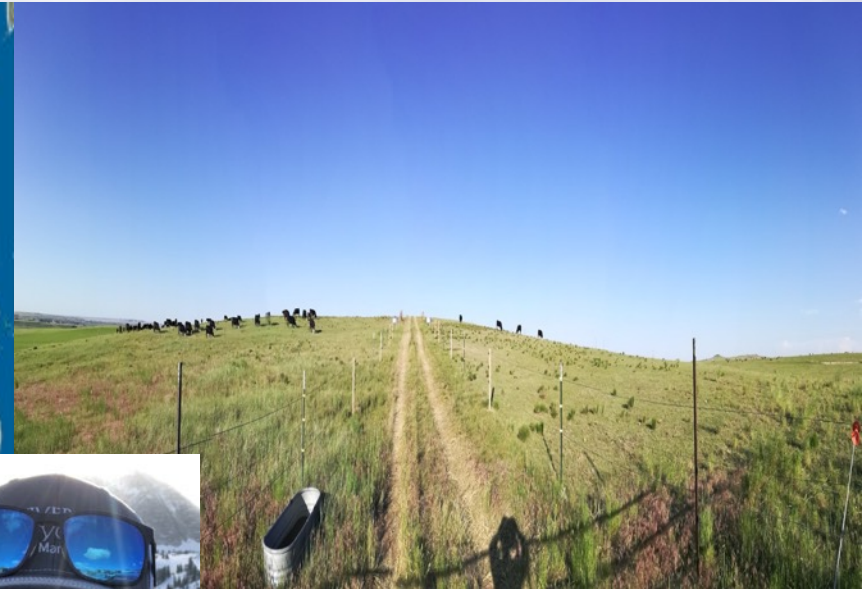
Sims Cattle Company, LLC

Questions





Usable Science for Producers: Helping Cattle Producers Make More Informed Decisions about Soil Health and Grazing



Timm Gergeni
tgergeni@uwyo.edu



UNIVERSITY OF WYOMING